

# IPS **e.max**<sup>®</sup> lithium disilicate

## The Future of All-Ceramic Dentistry

Material Science

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Practical Applications

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Keys To Success

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# Lithium Disilicate: The Future Of All-Ceramic Dentistry

## Introduction

Significant developments in all-ceramic materials have created wonderful opportunities for the fabrication of lifelike restorations that provide reliable, long-term results. To maximize the functional requirements of these materials, Ivoclar Vivadent, Inc. has introduced IPS e.max lithium disilicate glass ceramic, a material that provides optimum esthetics, yet has the strength to enable conventional or adhesive cementation. IPS e.max lithium disilicate has a needle-like crystal structure that offers excellent strength and durability as well as outstanding optical properties. IPS e.max lithium disilicate can be traditionally pressed or contemporary processed via CAD/CAM technology. Due to its strength and versatility, the material can be utilized for the following applications:

- Anterior/posterior crowns
- Inlays/onlays
- Veneers
- Thin veneers
- Telescopic crowns
- Implant restorations
- Anterior three-unit bridgework (press only)

## Material Science

### A. Processing

Glass ceramics are categorized according to their chemical composition and/or application. The IPS e.max lithium disilicate is composed of quartz, lithium dioxide, phosphor oxide, alumina, potassium oxide, and other components.

These powders are combined to produce a glass melt. Once the proper viscosity is achieved, similar to that of honey, the glass melt is poured into a separable steel mould of the proper shape.

The material is then left to cool in the mold until it reaches a temperature that no deformations occurs. This process produces minimal pores or other internal defects due to the glass flow process and provides for easy quality control due to the translucent nature of the glass. The blocks or ingots are produced in one batch depending on the shade and size of the materials (Figure 1). Overall, this composition yields a highly thermal shock-resistant glass ceramic due to the low thermal expansion that results when it is manufactured. The glass ingots or blocks are then processed using the lost-wax hot pressing techniques (IPS e.max Press) or state-of-the-art CAD/CAM milling procedures (IPS e.max CAD).

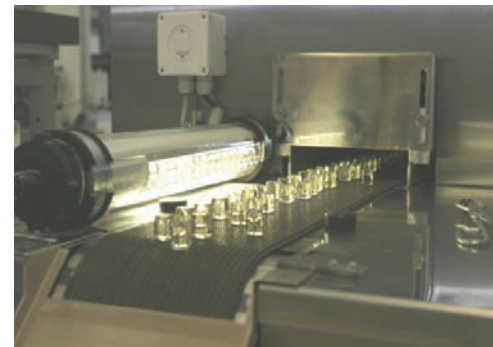


Figure 1

## IPS e.max CAD

The IPS e.max CAD “blue block” uses a two-stage crystallization process. The two-stage crystallization uses a controlled double nucleation process where lithium meta-silicate crystals are precipitated during the first step (Figure 2). The resulting glass ceramic demonstrates excellent processing properties for milling and tends to be a “blue color” in this state depending on the amount of added colorant. In a second heat treating step performed after the milling process has occurred, the meta-silicate phase is completely dissolved and the lithium disilicate crystallizes. This heat treatment occurs at approximately 840-850°C in a porcelain furnace. This process gives the definitive restoration a fine-grain glass ceramic with 70% crystal volume incorporated a glass matrix.

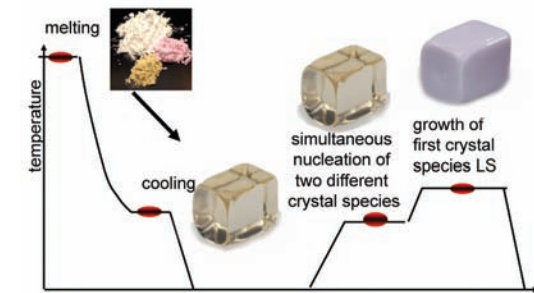


Figure 2

## IPS e.max Press

The IPS e.max Press material is produced similarly to the IPS e.max CAD as far as the formation of the initial glass ingots, as they are composed of different powders that are melted and cooled to room temperature to produce glass ingots. Following the glass formation, the ingots are then nucleated and crystallized in one heat treatment to produce the final ingots (Figure 3). These ingots are then pressed at approximately 920°C for 5-15 minutes to form a 70% crystalline lithium disilicate restoration.

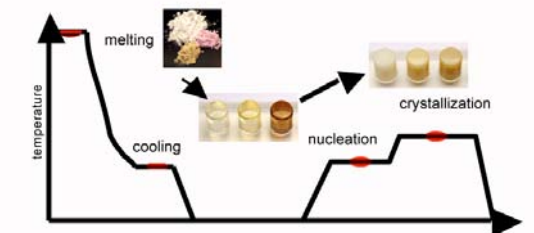


Figure 3

### B. Microstructure

## IPS e.max CAD

During processing, the IPS e.max CAD material has two crystal types and two microstructures that provide its unique properties during each phase of its use. The intermediate lithium meta-silicate crystal structure,  $\text{Li}_2\text{SiO}_3$ , allows the material to be easily milled without excessive bur wear. It is strong enough to be milled and has high tolerances and marginal integrity. In this state, the material will have a deeper blue when the final restoration has more chroma (Figure 4). The glass ceramic in the “blue” stage contains approximately 40 % volume lithium meta-silicate crystals with an approximate crystal size of 0.5  $\mu\text{m}$  as shown in Figure 5.



Figure 4

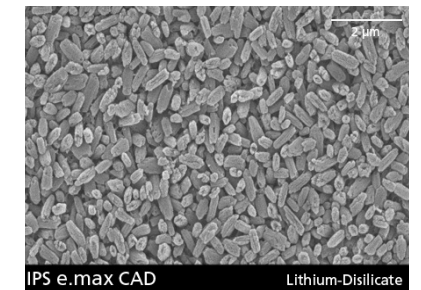


Figure 5

The final state contains a microstructure of lithium disilicate,  $\text{Li}_2\text{Si}_2\text{O}_5$ , which gives the restoration its mechanical and esthetic properties such as its high strength and range of translucencies and colors (Figure 6). The glass ceramic in this stage contains approximately 70 % volume lithium disilicate crystals with an approximate crystal size of 1.5  $\mu\text{m}$  as shown in Figure 7.



Figure 6

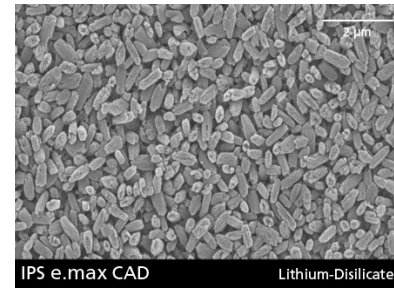


Figure 7

### IPS e.max Press

The pressable lithium disilicate is produced according to a unique bulk casting production method, which involves a continuous manufacturing process based on glass technology (melting, cooling, simultaneous nucleation of two different crystals, and growth of crystals) that is constantly optimized in order to prevent the formation of defects (Figure 8). The microstructure of the pressable lithium disilicate (i.e.,  $\text{Li}_2\text{Si}_2\text{O}_5$ ) material consists of approximately 70% volume of needle-like lithium disilicate crystals that are crystallized in a glassy matrix (Figure 9). These crystals measure approximately 3  $\mu\text{m}$  to 6  $\mu\text{m}$  in length.



Figure 8

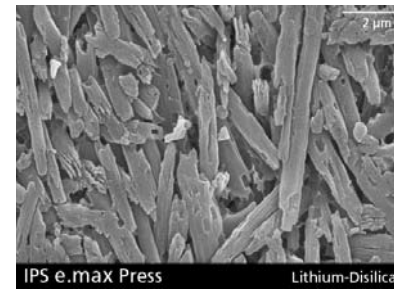


Figure 9

The crystals of both the IPS e.max Press and IPS e.max CAD are the same in composition. Both microstructures are 70% crystalline lithium disilicate,  $\text{Li}_2\text{Si}_2\text{O}_5$ , but the size and length of these crystals are different. This is why material properties such as CTE, modulus of elasticity, and chemical solubility are the same, yet the flexural strength and fracture toughness are slightly higher for the IPS e.max Press material.

### C. Strength

The basic physical properties for IPS e.max Press and IPS e.max CAD are displayed in Tables 1 and 2 below. The strength of both of these materials is greater than 360 MPa, which is over twice that of other ceramic materials that do not require any layering material (Figure 10).

CTE (100–400°C) [ $10^{-6}$ /K]	10.2
CTE (100–500°C) [ $10^{-6}$ /K]	10.5
Flexural strength (biaxial) [MPa]*	360
Fracture toughness [ $\text{MPa m}^{0.5}$ ]	2.25
Modulus of elasticity [GPa]	95
Vickers Hardness [MPa]	5800
Chemical solubility [ $\mu\text{g}/\text{cm}^2$ ]*	40
Crystallization temperature [°C]	840–850

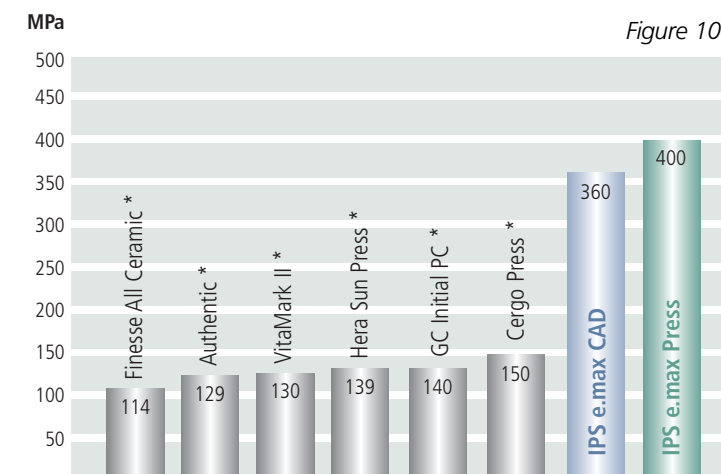
\*according to ISO 6872

Table 1

CTE (100–400°C) [ $10^{-6}$ /K]	10.2
CTE (100–500°C) [ $10^{-6}$ /K]	10.5
Flexural strength (biaxial) [MPa]*	400
Fracture toughness [ $\text{MPa m}^{0.5}$ ]	2.75
Modulus of Elasticity [GPa]	95
Vickers hardness [MPa]	5800
Chemical solubility [ $\mu\text{g}/\text{cm}^2$ ]*	40
Press temperature [°C]	915–920

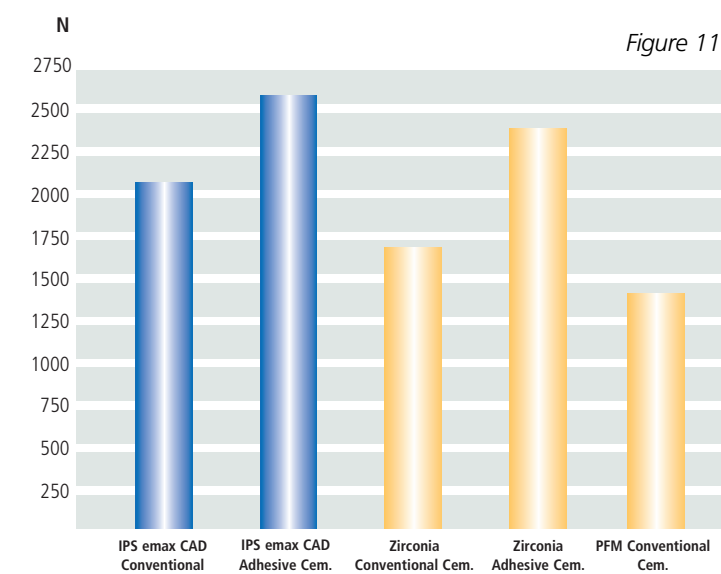
\*according to ISO 6872

Table 2



Comparison of the flexural strength of pressed ceramics

\* Not registered trademarks of Ivoclar Vivadent AG  
Source: R&D Ivoclar Vivadent AG, Schaan, 2005



Failure load of monolithic vs. layered crowns

Source: T. J. Hill et. al., "Cementation Effect on the Fracture Load of Two CAD/CAM materials" IADR 2009, abstract #0052, Miami.  
Source: T. Dasgupta et. al., "Fracture Load of Two PFM Veneering Techniques" IADR 2008, abstract #2323, Toronto.

This means that for a posterior crown fabricated to full contour using CAD methods, lithium disilicate offers 360 MPa of strength through the entire restoration. When fabricating using the pressing technique, these restorations deliver 400 MPa of strength throughout. As a result, restorations demonstrate a "monolithic" strength unlike any other restoration (Figure 11).

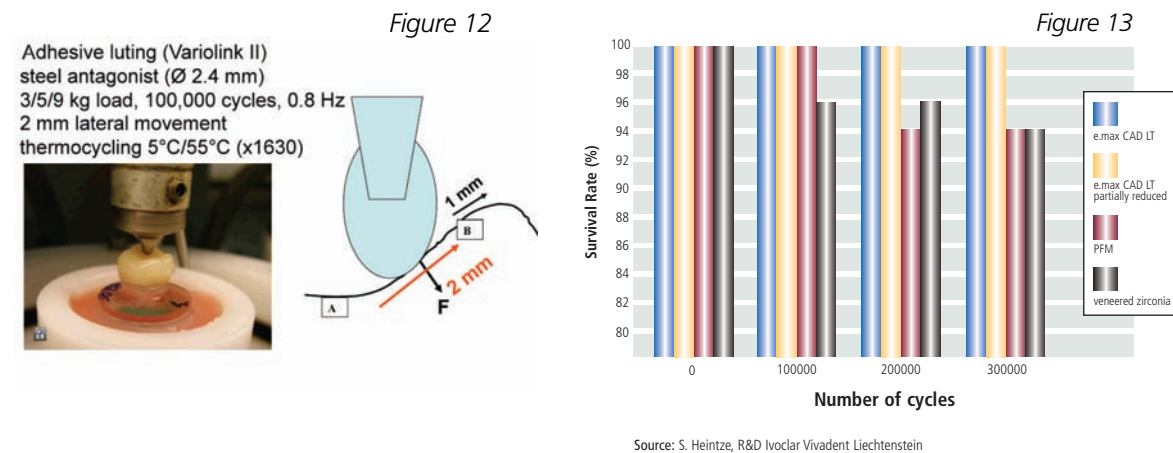
Overall, these materials demonstrate specific advantages to dentists and patients, including higher edge strength vs. traditional glass ceramic materials (i.e., can be finished thinner without chipping). Additionally the low viscosity of heated ingots enables pressing to very thin dimension (i.e., enabling minimal prep or no-prep veneers) and creation of the "chameleon effect" due to their higher translucency.



## D. Fatigue

Besides strength testing using a static load with a universal testing machine, subcritical eccentric loading using a chewing simulator (Willytec) (Figures 12 & 13); and long-term cyclic loading with a chewing simulator (eGa) have been performed to examine the nature of fatigue on these materials in comparison to others on the market. The results of these tests demonstrate that:

- The monolithic nature of the lithium disilicate material provides significant durability to the final restoration.
- Regardless of the in vitro test performed, in comparison to various restorative dental material for crowns (e.g., leucite glass ceramic, metal ceramic, zirconia), the lithium disilicate material demonstrates superior results



## E. Color and Translucency

From an esthetic standpoint, the lithium disilicate material is very versatile. As shown in Figure 14, it is available in four translucencies, providing a greater variety of different indications depending on the need of the restoration. The opacity is controlled by the nanostructure of the material. Scattering of light at the interfaces between the crystals and the glass matrix causes a higher opacity. If there is a similar refractive index of light between the crystals and the glass matrix, such as between the lithium disilicate crystals and the glass matrix, it is possible to achieve a very high translucency. If the refractive index between the crystals and the glass is high,

Translucency level	Indications								
	Table Tops <sup>1</sup>	Thin Veneers <sup>1</sup>	Veneers	Inlays	Onlays	Partial crowns	Anterior crowns	Posterior crowns	3-unit bridges <sup>1</sup>
High Translucency	✓	✓	✓	✓	✓	✓	✓	✓	✓
Low Translucency		✓	✓			✓	✓	✓	✓
Medium Opacity							✓	✓	✓
High Opacity							✓	✓	✓

\* the cut-back technique is not allowed for thin veneers and table tops  
<sup>1</sup> only with IPS e.max Press

Figure 14

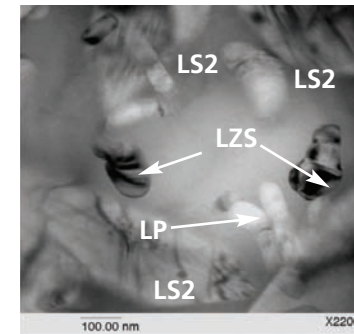
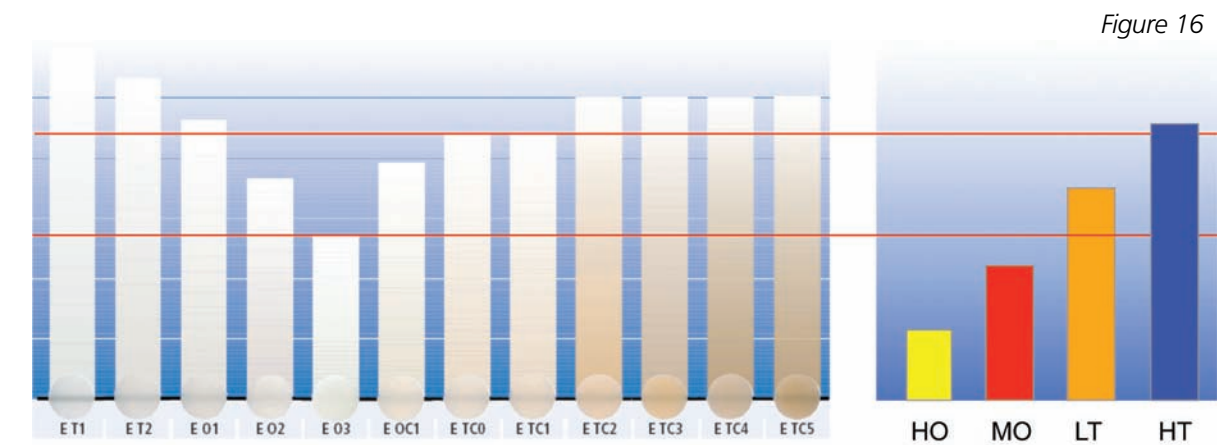
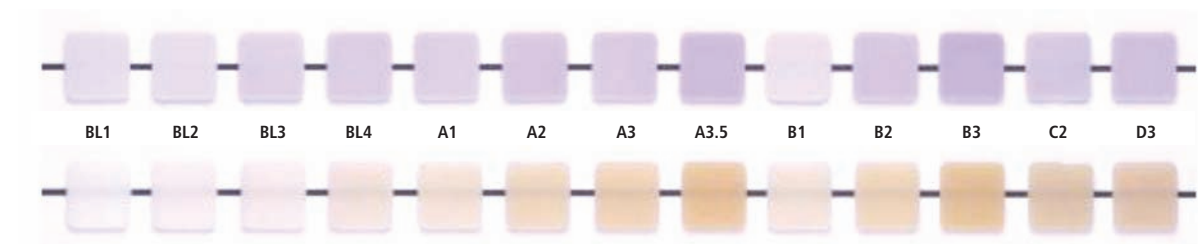


Figure 15  
Nano structure controls translucency. LS2 – Lithium Disilicate, LP – Lithium Phosphate, and LZS – Lithium Zinc Silicate crystals deflecting light to control translucency

then higher opacity results, as is the case with nano crystals (Figure 15) included for the high-opacity materials. Thus the opacity may be tailored for a variety of different applications to produce translucencies that are well accepted within the industry (Figure 16). The manufacturing processes used to control opacity have no influence on the mechanical properties such as the strength and modulus of the material.



The color in the lithium disilicate glass ceramics is controlled by coloring ions that are dissolved in the glass matrix. The color depends on the valency of the ions and the field surrounding the ions. Several ions are used to control the color in glasses. For example, the green or brown color in beer bottles is controlled this way, with brown beer bottles using a polysulfide complex of  $n\text{Fe}^{+2}\text{Sn}^{-2}$ , while green beer bottles use  $\text{Cr}^{+3}$  and  $\text{Fe}^{+2}$ . In lithium disilicate, the primary ions are  $\text{V}^{+4}/\text{V}^{+3}$  (blue/yellow),  $\text{Ce}^{+4}$  (yellow), and  $\text{Mn}^{+3}$  (brownish). For the IPS e.max CAD material, the vanadium (V) is in a valency of +4 due to the surrounding state conveyed by the lithium meta-silicate crystals. After milling and during the heat treatment, the primary crystal structure changes from lithium meta-silicate to lithium disilicate, the valency of the vanadium changes from +4 to +3 and the color given from these goes from blue to yellow. As the final color is a result of the concentration of ions and the influence of the matrix glass, controlling the melting conditions of the blocks are essential (Figure 17).



Comparison: IPS e.max CAD LT before and after crystallization

Figure 17

## F. Wear

Wear resistance and compatibility are critical properties of all dental materials. In the case of composites, there is concern regarding the wear resistance of the restorative material. With ceramics, the concern reflects on their compatibility with opposing tooth structures. The wear of the opposing enamel by lithium disilicate has been tested with the OHSU machine for the simulation of 5 years' worth of wear (Figure 18). In comparison to other ceramics and even enamel in this study, the wear of lithium disilicate was very low, showing a kind surface with respect to wear of any opposing dentition.

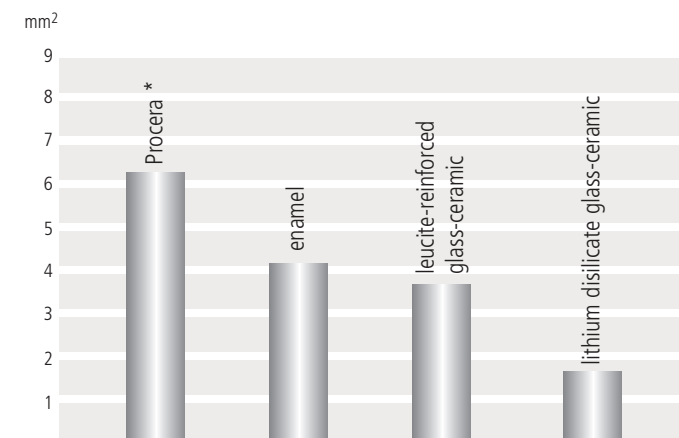


Figure 18

### Wear of enamel on the antagonist tooth

\* Not a registered trademark of Ivoclar Vivadent AG  
Source: Wear of Enamel against Dental Ceramics. Sorenson, et al. J Dent res. Vol 78, 1999 #909

## G. Biocompatibility

The biocompatibility of ceramic materials in the oral environment is tested using a variety of methods (e.g., cytotoxic testing and agar diffusion testing). In 2008, Brackett, Wataha, and others (Dental Materials 24 (2008) 450-456) examined the cytotoxic response of lithium disilicate dental ceramics. They concluded "In spite of the mitochondrial suppression caused by the lithium disilicate materials in the current study, these materials do not appear to be any more cytotoxic than other materials that are successfully used for dental restorations. The lithium disilicate materials were less cytotoxic than several commonly used composite materials (Fig. 4, [28]) and were comparable to cytotoxicity reported for several alloys [29] and glass ionomers [30]. Furthermore, the improvement of these materials over the course of several weeks of aging and the relative stability of the cytotoxic response post-polishing suggests that they will perform well clinically in the long term." Also, agar diffusion tests have been run in accordance to ISO 10993-5 guidelines and the results demonstrate the e.max materials are considered non-cytotoxic.

## Practical Applications

### Monolithic Ceramic Structures – Is there a structural advantage?

One of the primary challenges faced by today's dental restorative team is the need to deliver high-strength restorative options without compromising the esthetic outcome fueled by ever-increasing patient demands. The traditional approach, which employs a high-strength core material typically constructed from an oxide ceramic such as zirconia or alumina, has two distinct disadvantages. First, the substructure material generally exhibits high value and increased opacity compared to glass-ceramic materials. This presents some esthetic challenges, particularly in the case of conservative tooth preparation whereby the core material will be situated very close to the exterior surface of the restoration. Second, while the high-strength core material has excellent mechanical properties, the layering ceramic with which it is veneered has a much lower flexural strength and fracture toughness. As seen in Figure 19, the zirconia core, which has a flexural strength of 900 – 1000 MPa, comprises less than half the cross-sectional thickness of the restoration. The remaining dimension must be completed using a veneering material with a flexural strength of approximately 80 – 110 MPa depending on whether it is delivered through a powder build-up or by pressing. The obvious weak link in restorations of this design is the ability of the veneering material to resist chipping or fracturing during function. Additionally, restorations of this type rely heavily on the ability to achieve a strong bond interface between two dissimilar ceramic materials, oxide ceramic and silica based glass-ceramic. While this type of bond is not difficult to achieve, the quality of the bond interface can vary widely based on such factors as cleanliness of the bond surface, furnace calibration, user experience, etc.

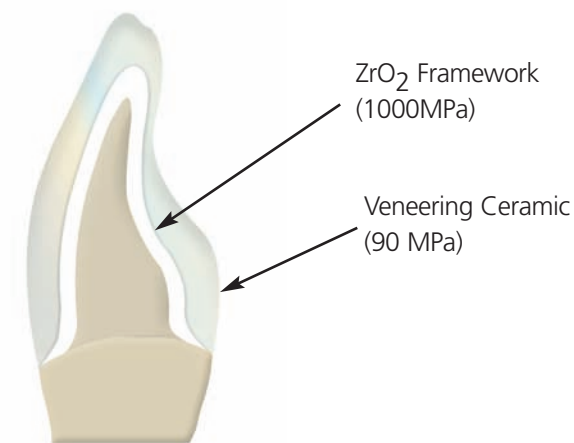


Figure 19 - Zirconia Supported Restoration

restorations only, and requiring the clinician to employ adhesive bonding techniques to reinforce their structures through load sharing with the underlying tooth.

The recent development of highly esthetic lithium disilicate glass-ceramic materials provides an answer to this dilemma. The 70% crystal phase of this unique glass-ceramic material imparts improved flexural strength (360 – 400 MPa), while at the same time refracting light in a very natural manner. This combination of strength and esthetics enables both an expanded range of indications and the ability to place restorations using conventional cementation protocols.

Monolithic glass-ceramic structures offer some distinct advantages in that they provide exceptional esthetics without requiring a veneering ceramic. By eliminating the veneered ceramic and its requisite bond interface, greater structural integrity can be achieved. Historically, the drawback to these restorations has been related to the relative strength of the available glass-ceramic materials. These materials typically have a flexural strength of 130 – 160 MPa, relegating them to use on single-unit

In many cases, restorations constructed from lithium disilicate materials can be completely fabricated using a monolithic approach (Figure 20). While this technique provides exceptional strength and esthetics, it often relies on characterization with surface colorants to achieve the final shade. In cases where in-depth color effects are desirable, a partial layering technique may be used (Figure 21). In this case—although no longer a purely monolithic structure—the resulting restoration is still exceptionally strong due to the large volume of core material versus traditionally layered restorations.

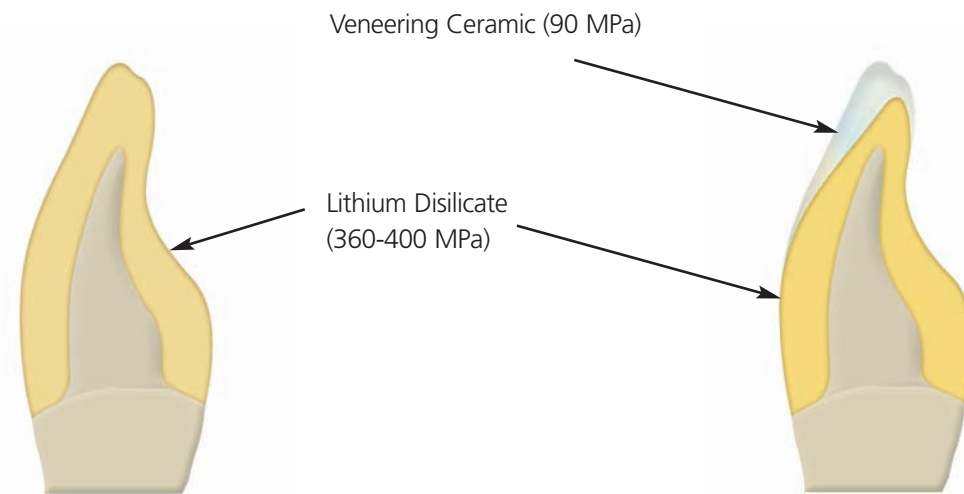


Figure 20 - Monolithic Restoration

Figure 21 - Partially Reduced Restoration

### Lithium Disilicate - Is this the answer to the minimal preparation restoration?

In today's environment of minimally invasive tooth preparation, dental laboratories and clinicians continuously search for new restorative materials that will fulfill not only the esthetic demands of their clientele, but also exhibit adequate strength and processing tolerance for the resulting "thin veneer" restorations. While not a new concept, the thin or "no prep" veneer has gained renewed emphasis by dental professionals searching for less invasive methods for restoring teeth. Unfortunately the traditional materials available for this type of restoration have been based on feldspathic glass-ceramic technology and are therefore limited by strength and their ability to be easily processed. For technicians, this means risk of fracture or chipping of the margins during laboratory fabrication; for clinicians, a delicate try-in and cementation process.

Pressed lithium disilicate offers an improved method for delivering thin veneer restorations. Because of the increased flexural strength, thin structures are easily created. These structures not only have adequate strength to withstand typical laboratory grinding processes, but also exhibit exceptional edge strength to minimize risk of chipping otherwise delicate margin areas.



Figure 22 - Thin Veneer Laboratory Fabrication Sequence

Because the press techniques used for lithium disilicate are not different than other restoration types (Figure 22), there is a comfort level for integrating these restorations into the typical laboratory's work flow. Additionally, due to the low viscosity of lithium disilicate during pressing, restorations can be accurately waxed to their final thickness of 0.3 mm without risk of incomplete pressings.

The Benefits:

- Minimally invasive preparation (preservation of tooth structure)
- Less discomfort for the patient
- High processing tolerance in both the laboratory and operator
- Increased edge strength for improved marginal integrity
- Proven press technology integrates perfectly into the laboratory work flow
- Best of both worlds--strength and esthetics

### Keys to Success

Whether delivered through a wax and press technique or processed using a CAD/CAM system, lithium disilicate restorations provide users with reliable restorative options for an expanded range of indications. Due to their unique physical properties, however, there are several "keys to success" that should be followed to ensure ease of processing and a predictable result. These key points are as follows.

IPS e.max Press:

1. **Restoration design** – like any dental restoration, those fabricated from lithium disilicate must meet certain design criteria to ensure strength and esthetic requirements are fulfilled. In the case of IPS e.max Press, this translates into designing wax-ups that meet specific dimensional needs based on restoration type and whether or not it will be veneered with a layering ceramic such as IPS e.max Ceram. These specific recommended dimensions are outlined in Figure 23. While it is probably obvious to most that a molar crown requires greater thickness than a thin veneer due to the increased functional stress it must withstand, what may not be as readily understood is the effect that this thickness has on the shade of the definitive restoration. By following the recommended preparation guidelines and minimal thickness, a strong esthetic restoration can be easily achieved.

		Thin Veneer	Veneer	Partial crowns	Crowns		Bridges	
					Anterior	Posterior	Anterior region	Premolar region
	Material thickness circular	0.3	0.6	1.5	1.2	1.5	1.2	1.5
	Material thickness incisal/occlusal	0.4	0.7	1.5	1.5	1.5	1.5	1.5
	Material thickness circular	–	0.6	1.5	1.2	1.5	1.2	1.5
	Material thickness incisal/occlusal	–	0.4	0.8	0.4	0.8	0.8	0.8
	Material thickness circular	–	–	–	0.6	0.8	0.8	0.8
	Material thickness incisal/occlusal	–	–	–	0.6	0.8	0.8	0.8
	Design type	–	–	–	supporting the tooth shape			
	Connector dimensions	–	–	–	–	–	16 mm <sup>2</sup> (use IPS Connector)	16 mm <sup>2</sup> (use IPS Connector)

dimensions in mm

Figure 23 - Recommended Dimensions for IPS e.max Press



2. **Waxing and finishing** – because of the increased hardness of lithium disilicate restorations over traditional pressed materials, greater care should be given to produce a highly detailed wax-up that will require minimal finishing. This means that for the monolithic structure, precise contours and contact patterns should be developed in the wax pattern. For restorations that will be subsequently augmented with veneering materials, the area of tooth reduction should be established in the wax-up instead of in the pressed structure, as is commonly the practice with softer materials. Regardless of restoration type, this will help limit grinding to the minimum necessary for seating the pressed structure and recontouring the sprue attachment area. When grinding the restoration, instruments should be used which minimize heat generation and vibration. Figure 24 gives examples of grinding instruments which have been tested and approved for use with lithium disilicate restorations.

Smoothing out of attachment points (e.g. sprues)					
	Komet Brasseler	Eve	Edenta	Jota	Bredent
Finishing of surfaces					
	Komet Brasseler	Eve	Edenta	Jota	Bredent
Finishing of margins					
	Komet Brasseler	Eve	Edenta	Jota	Kenda

Figure 24 - Recommended Grinding Instruments

3. **Press furnace** – While it is possible to press lithium disilicate restorations in virtually any press furnace, the quality of the pressing varies greatly depending on furnace design. A press furnace that automatically senses the completion of the press cycle, such as those from Ivoclar Vivadent, is highly recommended to ensure a dense, clean pressing is achieved. Unlike other pressable materials, lithium disilicate will lightly absorb some investment materials at the contacting surfaces during pressing. This reaction layer between the glass-ceramic and the investment represents a dirty bond surface that must be cleaned prior to veneering, shading, or glazing. In automatic press furnaces such as the EP5000 (Figure 25) or EP3000 from Ivoclar Vivadent, this reaction layer is very light and easily removed. With press furnaces that do not automatically sense the complete filling of the mold, the user must estimate a pressing time. If this educated guess results in too little pressing time, the furnace will abort the program prior to complete filling of the investment mold. If the pressing time is too long, excessive reaction layer will develop, resulting in either excessive clean-up effort or in extreme cases a pressing that is unusable.



Figure 25 - EP5000 Pressing Furnace

4. **Removing reaction layer** – as previously discussed, reaction layer is a normal byproduct of any lithium disilicate pressing and must be thoroughly removed to ensure a clean bond surface for veneering material, stain, or glaze application. Effective removal of reaction layer is a two-step process beginning with immersion of the pressed structure in a weak acid solution (i.e., IPS e.max Invex Liquid). This step is critical to the proper identification and removal of the reaction layer, which is sometime difficult to see on the pressing. Immersion in Invex Liquid for 20-30 minutes will etch the surface of the reaction layer, turning it a chalky white color for easy identification. Additionally, this weak acid solution will soften the reaction layer without adversely affecting the underlying glass, so that it can be easily blasted from the surface using 100 µm aluminum oxide at 1-2 bar pressure. It is critical to use 100 µm blasting medium rather than 50 µm, as the smaller particle size is not as effective in removing the reaction layer and can leave residual material on the surface.

IPS e.max CAD:

1. **Restoration design** – the design principles for IPS e.max CAD are very similar to those for IPS e.max Press. For substructure millings, the minimum thicknesses are automatically produced through the default settings in the design software. This requires the operator to simply decide areas where additional support is required and modify the contours through design tools within the software. In the case of monolithic structures, the minimum thicknesses shown in Figure 26 must be followed to ensure strength and esthetic requirements are met.

			Veneer	Partial crowns	Crowns		
			Anterior	Premolar	Molar		
	Material thickness	circular	0,6	1,5	1,2	1,5	1,5
	Staining technique	incisal/occlusal	0,7	1,5	1,5	1,5	1,5
	Material thickness	circular	0,6	1,5	1,2	1,5	1,5
	Cut-back technique (after reduction)	incisal/occlusal	0,4	1,3	0,4	1,0	1,3
	Material thickness	circular	–	–	0,8	0,8	–
	Layering technique	incisal/occlusal	–	–	0,8	1,0	–
	Layering technique	Design type	–	–	supporting the tooth shape		–

Figure 26 - Recommended Dimensions for IPS e.max CAD

dimensions in mm

2. **Milling Strategy** – due to the unique physical properties of e.max CAD, milling in the pre-crystallized state can be easily achieved using the standard milling strategies in all approved milling systems. Depending on the milling system used, the fit of the restoration can vary as a result of differences in the dimension of the milling tools. This fit difference is generally easy to compensate for by adjusting the spacer parameter within the CAD design software.

An important point of discussion regarding the fit of IPS e.max CAD restorations relates to the spindle speed and feed rate of the milling machine. Since IPS e.max CAD is a fully sintered glass-ceramic material, even in the pre-crystallized state, highly aggressive milling can induce surface flaws that degrade the final strength and also potentially chip marginal areas. Although the proper milling strategy is integrated into the software of the approved milling machines, sometime users will try to speed the process by “fooling” the software into thinking a different material is being milled. These faster milling strategies are almost always detrimental to the strength and marginal integrity of the milled restoration and must be avoided.

3. **Finishing** – because IPS e.max CAD restorations are dimensionally stable during the crystallization process, users can fully seat and finish the ceramic in the pre-crystallized state, where it is softer and easy to manipulate. Although finishing can also be accomplished in the crystallized state using the same grinders as those used for IPS e.max Press (Figure 27), it is certainly less desirable due to the increased hardness of the material. For finishing of most surfaces, standard laboratory grinders can be used. If the CAD design has been properly accomplished, bulk grinding should not be necessary, and finishing should be limited to simple sprue reduction and adjustment of occlusal and proximal contacts. For finishing of margins, silicone polishers are preferred. As previously stated, pre-crystallized lithium disilicate is a fully sintered glass-ceramic and therefore must be handled appropriately to prevent chipping of the margins. Silicone polishers will permit easy adjustment of marginal areas to a defined edge, without generation of heat and vibration that could lead to chipping. Examples of appropriate silicone polisher are contained in Figure 27. Any debris generated during adjustment of the restoration along with residual lubricant from the milling process should be cleaned prior to crystallization.

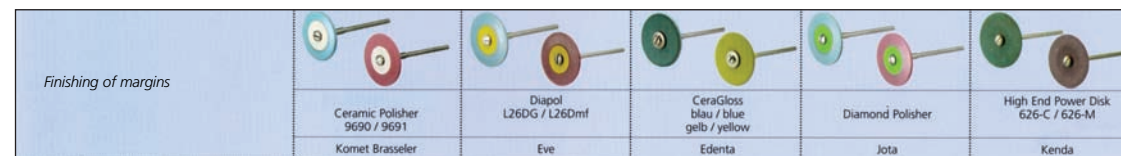


Figure 27 - Silicone polishers for finishing IPS e.max CAD Margins

4. **Crystallization** – IPS e.max CAD restorations are uniquely suited to CAD/CAM processing as the materials can be milled in a softened (pre-crystallized) condition where they are easily processed with typical milling strategies, and then converted through a simple heat treatment process to achieve final strength, hardness, and shade characteristics. Unlike other high-strength ceramics, this process does not require an additional investment in costly lab infrastructure, but rather is accomplished using standard porcelain furnaces. During the crystallization process, the ceramic is converted from a lithium metasilicate crystal phase to lithium disilicate. Thru this dynamic heat treatment, the lithium metasilicate crystals, which provide stability during the milling process are absorbed back into the glass matrix and used as the raw materials for growth of the lithium disilicate crystals. The resulting restoration exhibits exceptional strength and esthetics.

The key to successful crystallization of IPS e.max CAD restorations lies in two factors: 1) the ceramic furnace utilized and 2) the method by which the material is supported during firing. Any standard porcelain furnace may be used as long as it meets certain criteria. Ideally, a two-stage firing program should be utilized, particularly if the “speed crystallization” option is desired. Additionally, the furnace must be capable of a controlled slow cooling so that the proper growth of the lithium disilicate crystals is achieved. The Programat line of furnaces from Ivoclar Vivadent is ideally suited to this type of firing program and the crystallization parameters are preset at the factory for all current furnace models.

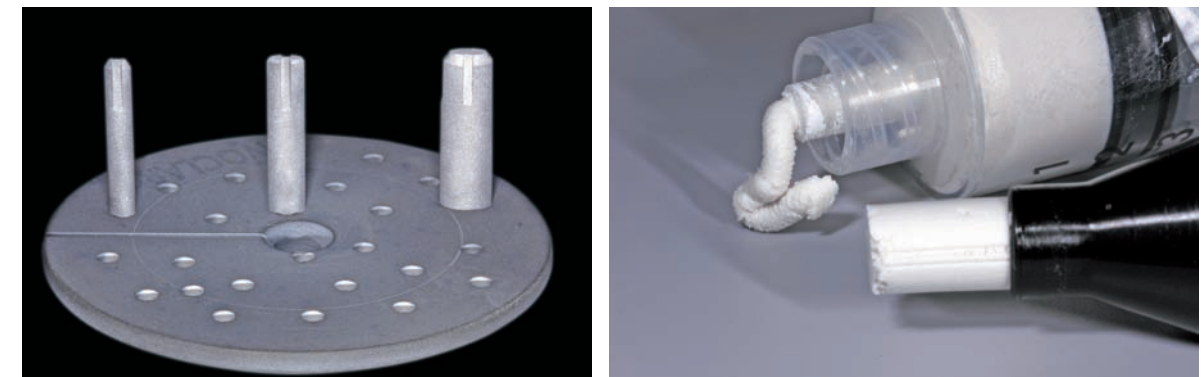
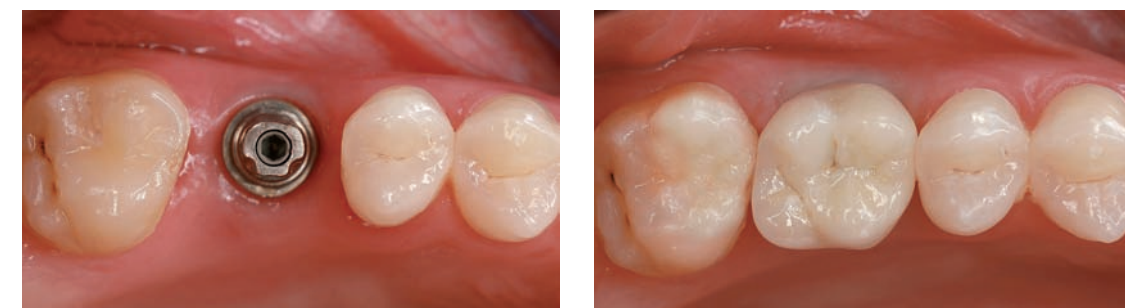


Figure 28 - Silicone Nitride Firing Tray and Object-fix Materials

As previously stated, the support mechanism during the firing process is equally important (Figure 28). IPS e.max CAD restorations must be fired on a silicone nitride firing tray to achieve the proper temperature profile and completely supported by a refractory material (IPS Object-Fix) to prevent distortion during firing. The use of other trays and support media is not indicated, as they will not permit the proper firing and subsequent crystal growth. Object-Fix is available in both a paste and flowable consistency (depending on the preferences of the user) and must fully support the internal aspects of the restoration during the firing process.

## Conclusion

The IPS e.max lithium disilicate offers exciting new opportunities in restorative dentistry. The material's strength and optical properties offer dental professionals multiple options for achieving highly durable and esthetically pleasing restorations.



Before

After



# IPS® e.max

**all ceramic  
all you need**



veneers



thin veneers



inlays/onlays



crowns

**IPS e.max® lithium disilicate**  
all you need for single  
unit restorations

**IPS e.max lithium disilicate offers:**

- Unique patented formulation
- Outstanding esthetics
- Conventional and adhesive cementation
- Indicated for inlays, onlays, crowns and veneers

**IPS e.max®**  
all ceramic all you need

100% CUSTOMER SATISFACTION  
GUARANTEED!

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627329 Rev. 0 2/2009

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