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## **Evaluation of surface treatments by self glaze, over glaze and a polishing agent on the porcelain surface modified with diamond rotary instrument-an in vitro study**

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**Abstract**--The purpose of this study is to evaluate effect of a) Self glaze b) Over glaze and c) Polishing on porcelain surface which is subjected to grinding with a diamond rotary instrument. To test this theory 40 ceramic fused to metal disc samples were fabricated. The ceramic material used was Ivoclar Dsign. The discs were of 10mm X 3mm of which 2mm is metal substructure and 1mm is of porcelain. The specimens were divided into four groups of 10 samples each. The first group was left as fired or unglazed. The remaining three groups were subjected to surface modification with sintered diamond bur at 15000 rpm per minute with even pressure. Each of the three groups was treated with diamond polishing paste, self glaze and overglaze

respectively. The surface of all the four groups were evaluated under optical microscope and scanning electron microscope. Optical microscope observation revealed that Group-I (as fired) had the surface of the specimens appearing to be pitted, rough with irregularities and there was no evidence of surface cracks. Group II (polished with diamond bur) had surface appeared to be very smooth. There was no evidence of cracks on the surface. Group III (self glazed) had surface of the specimens appeared to be less smooth. A few voids and surface irregularities were seen. Cracks were visible on the surface. Group IV (over /Glazed) had surface of the specimens, appearing to be smooth and few voids could be seen. There was no evidence of surface cracking. Scanning electron microscope revealed that Group I had surface appearing to be very rough, chipped and voids were visible. There was no evidence of surface cracks. Group II had surface appearing to be very smooth and there was no evidence of surface cracks. Group III had surface which showed evidence of microcracks occurring at varying lengths (in microm). Group IV had surface appearing to be very smooth and there was no evidence of surface cracks. Over glazed samples appeared smooth without micro cracks on their surface. Polished group of samples also appeared to be smooth and did not exhibit any microcracks. Self glazed group of samples exhibited fine surface cracks of varying lengths. The optical microscope analysis and scanning microscopic analysis results correlated with each other.

**Keywords**---surface roughness, self glaze, over glaze.

## **Introduction**

The term ceramics is derived from the Greek word `Keramos' (which literally means art of pottery or burnt stuff/earthenware ); meaning `pertaining to pottery, especially as an art` ; or `Keramikos' which means `earthen'. (Ceramic art comprises of all art objects made of baked clay such as vases , urns, cups, statuettes etc, and includes all varieties of artistic earthenware and porcelain[1]. Porcelain has been available as a restorative material for over 150 years . it is an ideal material for the replacement of lost tooth, because of its aesthetic quality, low thermal and electrical conductivity, coefficient of thermal expansion which is similar to that enamel and dentin and its resistance to degradation in the oral environment [2].

Porcelain used as a restorative material should be well glazed because unglazed porcelain is prone to plaque accumulation. Most of the published information regarding the reaction of soft tissues around porcelain, indicates that tissues can tolerate glazed porcelain better than other materials. Unglazed porcelain is highly abrasive causing significantly greater wear on opposing surfaces of teeth than the glazed porcelain[3]. The potential for porcelain restorations to abrade opposing occlusal surfaces is a problem of great concern. Preparing a ceramic crown for final placement in a patient's mouth, often requires adjustment of the porcelain surface which is already glazed. This grinding breaks the glazelayer and create a

rougher surface promoting plaque formation, gingival inflammation and adverse soft tissue reaction or may increase the wear of the opposing dentition or restorative material and requires the surface to be reglazed or alternatively, polished[4-12].

Subjecting the ceramic material to another firing cycle has a potential for adversely changing the porcelain structure and it is also time consuming. Polishing after adjustment procedures, is necessary to improve flexural strength and appearance of the restoration[13-16]. Therefore, polishing techniques using various diamond points, rubber sheets and abrasive discs have been developed, polishing kits are also available for the purpose of polishing as an alternative to reglazing[2][17-24]. The purpose of this study is to evaluate the surface roughness of the dental porcelain specimens which are selfglazed, overglazed and treated with a polishing agent after grinding with diamond rotary instrument.

### **Aims of the study**

The aim of the study is:

- To evaluate the effectiveness of self glazing, over glazing and polishing with commercially available polishing material on roughened porcelain specimens by observing under an optical microscope.
- To determine the presence or absence of surface cracks on the porcelain specimen surfaces due to the above surface treatments by using a scanning electron microscope(SEM).

### **Materials and Methods**

A plastic sheet of 2mm thickness measuring 20cmx10cm was selected. 10 circular perforations of 10mm diameter in a row using a laser beam was made in the plastic sheet. Two such rows totaling 20 perforations were created to prepare wax disc models (Fig1). (fig2,3,4,5) (fig6,7). The prepared samples were tried into the circular perforations of the plastic sheets, to verify the correct diameter, The plastic sheet stencil would also help in the study by stabilizing the samples within the perforations when subsequent modifications of ceramic surface should be undertaken. samples used in this study were ceramic fused to metal discs. Discs were of 10mm in diameter and 3mm thickness. The metal portion was of 2mm while 1mm thick of Ivoclar IPS Design porcelain was fused it. The metal discs were cast by lost wax technique. Thus preparation of the test specimens comprised of making wax discs of 10mmx2mm which were invested in a casting ring, dewaxed and later molten nickel chromium alloy was flown into the mould. 40 test specimens of porcelain fused to metal disc were prepared

### **Modification of prepared specimens**

Thirty of the above samples were subjected to uniform roughening of the porcelain surface. Roughening of the surface was carried out by using medium grit sintered diamond bur at a constant speed at 15,000rpm with even pressure, while the disc was held within the perforation of the plastic stencil. Roughening

was carried out with the help of laboratory type of digital micromotor and hand piece (Fig 8). Thus there were 10 unmodified ceramic fused to metal discs and 30 porcelain surfaces modified ceramic fused to metal discs. For the convenience of study unmodified batch of discs was labeled as GROUP 1. 30 discs with surface modifications were divided into batches of 10 each and were labeled. GROUP II, GROUP III and GROUP IV.

### Technique of surface treatments

#### GROUP-1: no treatment

- GROUP II: polishing was done using diamond polishing paste on felt wheels for five minutes
- GROUP III: the samples were subjected to self glazing at 830°C without any surface application.
- GROUP IV: the modified samples were overglazed with Ivoclar Design paste.

Forty specimens were then tested with optical microscope as well as Scanning Electron Microscope to study the effect of various surface treatment on the roughened porcelain surface

### Process parameters

Table 1  
Process parameters

Program Name	Total temperature T	Starting temperature t	Holding temperature H	Stand by temperature B	Total time s	Vaccum	
						V <sub>1</sub>	v <sub>2</sub>
Oxidation	910 <sup>0</sup>	80 <sup>0</sup>	1min	403 <sup>0</sup>	6mints	450 <sup>0</sup>	889 <sup>0</sup>
1 <sup>st</sup> opaque	900 <sup>0</sup>	80 <sup>0</sup>	1min	500 <sup>0</sup>	6mints	600 <sup>0</sup>	899 <sup>0</sup>
2 <sup>nd</sup> opaque	890 <sup>0</sup>	80 <sup>0</sup>	1min	403 <sup>0</sup>	6mints	450 <sup>0</sup>	889 <sup>0</sup>
1 <sup>st</sup> dentin build up	890 <sup>0</sup>	60 <sup>0</sup>	1min	403 <sup>0</sup>	6mints	450 <sup>0</sup>	889 <sup>0</sup>
Inscical build up	870 <sup>0</sup>	60 <sup>0</sup>	1min	403 <sup>0</sup>	9mints	450 <sup>0</sup>	869 <sup>0</sup>
2 <sup>nd</sup> dentine/ insical corrective	870 <sup>0</sup>	60 <sup>0</sup>	1min	403 <sup>0</sup>	9mints	450 <sup>0</sup>	869 <sup>0</sup>
Glaze firing with glaze material	830 <sup>0</sup>	60 <sup>0</sup>	1min	403 <sup>0</sup>	4mints	450 <sup>0</sup>	829 <sup>0</sup>
self glaze firing	870 <sup>0</sup>	60 <sup>0</sup>	1min	403 <sup>0</sup>	4mins	450 <sup>0</sup>	869 <sup>0</sup>

### Preparation of specimens for viewing under optical microscope

The porcelain samples to be viewed under the optical microscope were cleaned in acetone solution and air dried. Sample was placed on the rigid platform which was adjusted to the correct position. A low power objective (50 x in case of optical

microscope) was selected and the specimen focussed. Once the field was focused, the power was changed to 100 X for further observation.

### **Preparation of samples for viewing under scanning electron microscope (fig.16)**

The samples to be viewed under an SEM were first immersed in acetone solution for few minutes. The samples were taken out of the solution and air dried. Once dried, Double sided adhesive tape was used to mount the samples on brass stubs. The specimens were ready to be coated with an electron- conducting material. Gold was used as the coating material (fig11,fig12,fig 13). Gold was available in the form of a metallic plate and placed in a Ion sputtering device along with the brass stubs loaded with the samples and the procedure of coating started. An ionised gas plasma formed inside the device which impinged on the gold metallic plate and the atoms were sputtered off the target and deposited on the sample surfaces as a thin layer. This gold coating would prevent the electrons accumulating on the surface of the samples which is known as 'Charging'.(Charging will seriously limit the useful magnification and resolution obtainable. This can be overcome by coating the sample with a thin layer of conductive material such as gold).Immediately after coating the specimens were observed under scanning electron microscope.

### **Results**

The porcelain specimen surfaces which were divided into four groups were examined under an optical microscope and scanning electron microscope for presence or absence of surface cracks.

#### **Optical microscope analysis of the specimens**

Optical microscope works on the principle of light microscopy. The light is used as a source for viewing the specimens. The specimens were observed under 100 x magnification.

- Group I - The surface of the specimens appeared to be pitted, rough with a lot of irregularities and there was no evidence of surface cracks.
- Group II - The surface appeared to be very smooth. There was no evidence of cracks on the surface.
- Group III - The surface of the specimens appeared to be less smooth. Few voids and surface irregularities were seen. Cracks were visible on the surface. These microcracks are very fine in nature and are occurring at different lengths. In some samples fragments could be seen completely fractured away leaving a ragged chip on the surface.
- Group IV - The surface of the specimens appeared to be smoother and few voids could be seen. There was no evidence of surface cracking.

According to optical microscope analysis there was evidence of surface cracks occurring on the specimens which are subjected to self glazing treatment after their surfaces were ground and polished. The self glazed, polished, and overglazed

sample surfaces appeared to be smooth and there is no evidence of microcracks on their surfaces.

### **SEM analysis of the specimen surfaces**

After the samples were examined under an optical microscope for presence or absence of surface cracks the samples were reexamined under an SEM at higher magnifications (500x, 750x and 1000x & 1500x). The samples were gold coated prior to viewing under scanning electron microscope.

- Group I - Surface appeared to be very rough, chipped and voids are visible. There was no evidence of surface cracks.
- Group II - The surface appeared to be very smooth and there was no evidence of surface cracks.
- Group III -. The surface showed evidence of microcracks which were occurring at varying lengths (in  $\mu\text{m}$ ). The surface showed fragments which seemed to be completely fractured away leaving a ragged chip on the surface. The microcracks were very fine in nature. Large variation in levels of cracking were also observed. On comparison of various samples the average level of cracking observed is  $4204 \mu\text{m} / \text{mm}^2$ .
- Group IV - Surface appeared to be very smooth and there was no of surface cracks.

On comparison of both the microscopic analysis it was observed that the findings of optical microscope analysis and SEM analysis correlated with each other. The groups which were modified with diamond sintered bur and selfglazed (Group-III) exhibited surface cracking. The surface cracks were very fine in nature and were occurring at varying lengths. The average level of cracking observed is  $4204 \mu\text{m} / \text{mm}^2$ . Surfaces of as fired/unglazed group samples (Group I) appear to be rough. Surfaces of modified and polished group of samples (Group II) appear to be very smooth and surfaces of overglazed (Group IV) samples also appeared to be very smooth and there was no evidence of cracks on sample surfaces.

### **Discussion**

Many a time the ceramic restorations require modifications before luting, to correct the occlusal interferences and improve esthetics. Such adjustments will result in rougher surface and inferior surface properties of the restoration. A rough surface may promote plaque formation and may increase abrasion of opposing teeth while inferior surface properties result in fracture of the restoration. Therefore various methods were available to improve the ceramic surface after necessary adjustments, however there has been no agreement on any one method being superior to the other. Several studies have compared the difference in effect of polishing techniques with that of autoglazing. In the present study Incisal Porcelain has been selected as the material for surface evaluation because it is the material of choice to cover the outer surface of the ceramic restorations. In the present study the above porcelain samples were divided into four groups of ten each.

- Group I : as fired/unglazed

- Group II ;modified and polished with diamond polishing paste
- Group III : modified and self galzed
- Group IV: modified and overglazed.

The samples were observed under optical microscope for evaluation after each surface treatment. The samples were also observed under scanning electron microscope and the results were correlated. The optical microscope analysis showed the presence of cracks on the groups of sample surfaces which were modified and then self galzed (Group III). There was no evidence of cracks on the other groups of samples. The as fired or unglazed group of samples (Group I) appear to be pitted and rough. Polished group of samples (Group II) appeared to be as smooth as the overglazed (Group IV) sample surfaces.

All samples were later observed under scanning electron microscope. The as fired group of samples (Group I) appeared to be rough and pitted. The samples which were modified and polished using diamond polishing paste (Group II ) appeared to be smooth with presence of few voids. The overglazed samples(Group IV) also appeared to be smooth. This result coincided with the study of Sulik and Plekavich et al [17]. who reported that with a well-condensed porcelain, the surface achieved by polishing could be as smooth as that of a glazed surface. The surfaces of samples which were modified and then self glazed (Group III) exhibited surface cracks of varying lengths. The surface cracks were very fine in nature. In some areas the material fragments were fractured away, leaving a ragged appearance. These results coincided with the study of Edge and Wagner[25]who reported that surface cracking was identified in ground and then self glazed surfaces of dental porcelain.

The samples which come under the groups of, as fired (Group I) and ground and polished with diamond polishing paste (Group III) exhibited no surface cracking. This study coincided with the results of Edge and Wagner [26]. In addition to the above, samples were also overgalzed (Group IV) .The surface of these samples also appeared to be very smooth and did not exhibit any cracking. This result coincided with the study of Nasser Barghi and Lee Alexander [3] who reported that a smooth porcelain surface could be obtained by glazing after grinding and there was no need for polishing with a rubber wheel prior to glazing. The polished samples (Group II ) appeared to be as smooth as the overglazed (Group IV) samples which agreed with the results of David A Newitter&Christensen et al[26] who reported that smooth surfaces could be obtained with finishing wheels followed by polishing paste in the absence of glazing. Klausener et al<sup>2</sup>. and Raimando et al[27] reported that a dental practitioner can choose between several different polishing methods to achieve a surface equal to or better than overglazing.

A porcelain restoration placement in a patient's mouth may involve grinding and polishing. Finishing the surface of ceramic materials may involve contact with a rotating wheel, producing multipoint surface grinding. This procedure generates numerous cracks that can result in chipping of the surface. The abrasive material has impact on the surface, producing contact forces that caused crushing of the material, plastic flow and elastic recovery of the material. As the abrasive contacts the surface of the material, compressive stresses can be generated and the area of

compressive stress beneath each abrasive particle can overlap, producing a layer of compression. This compressive layer can act to partially close an existing surface crack. This can be the reason for the group of samples which were modified and polished (Group II) not exhibiting any cracking on their surfaces.

In the group of samples which were subjected to modification and then self glazed( Group III) the surface exhibited microcracks. During the procedure of grinding and polishing, compressive residual stresses were produced which created a compressive layer that can close an existing surface crack. When the samples were subjected to selfglazing the compressive residual stresses might be relieved thereby exhibiting the microcracks on the surface. These microcracks which occurred on the sample surfaces of modified and selfglazed samples could lead to surface roughness of the porcelain material and result in chipping . When this chipped surface of porcelain comes in contact with the opposing natural teeth it would result in wear of opposing occlusal surfaces.

From the discussion, it can be concluded that microcracks are seen on the surfaces of modified and selfglazed samples. According to various studies a smooth surface could be obtained with polishing as in case of the overglazing. Therefore, the restorations which need adjustments can be subjected to polishing methods instead of reglazing it again. Further research may be done with other materials like body porcelain and other brands of porcelain and also in the form of crowns of normal thickness. After subjecting them to various surface treatments like self glazing, overglazing and polishing , SEM study can be done and the results can be evaluated. From this further research, the various surface treatments that a porcelain surface can be subjected to could be developed there by providing more information to the clinicians using these materials.

### **Summary and Conclusion**

This study evaluated the effect of self glazing, polishing and overglazing on modified Incisal porcelain surfaces, by microscopic analysis. The product which was used was Ivoclaripdsign. A total of 40 specimens in the form of discs were fabricated. The specimens were divided into four groups each having 10 specimens. Group I was left as they were while other three groups were subjected to experiment. The specimens were first observed under an optical microscope and later under a scanning electron microscope after experiments. The results were compared and evaluated. It was concluded that:

- The optical microscopic analysis and scanning electron microscopic analysis results correlate with each other.
- The over glazed samples appear to be smooth and do not exhibit any micro cracks on their surfaces.
- The sample surfaces of modified and polished groups also appear to be smooth and do not exhibit any cracking.
- The porcelain surfaces that were modified and the self galzed exhibited the formation of fine surface cracks. These cracks were occurring at varying lengths and the average levels observed was  $4204 \mu\text{m}/\text{mm}^2$
- These cracks were not observed in samples which were polished and over glazed.

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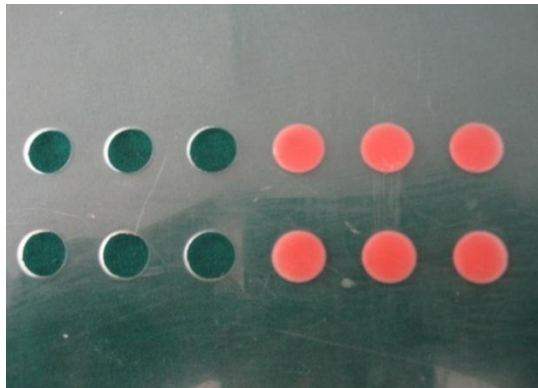


Figure 1. Plastic stencil used for the preparation of Specimens



Figure 2. Spruing of specimens



Figure 3. Wax Elimination procedure

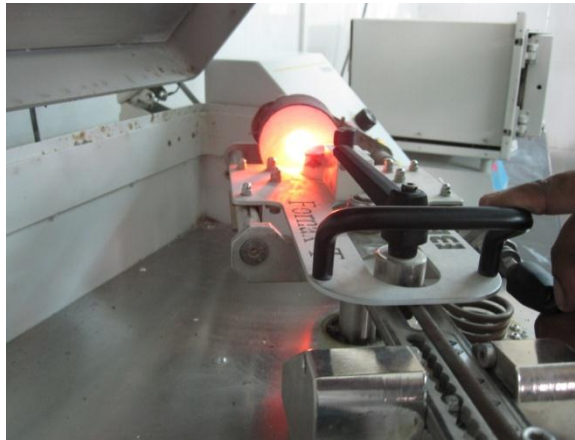


Figure 4. Induction costing procedure



Figure 5. Castings retrieved from the casting ring



Figure 6. Ceramic furnace



Figure 7. Specimens of metal fuse to ceramic



Figure 8. Digital Micro Motor and Hand Piece with sintered diamond bur



Figure 9. Optical microscope



Figure 10. Scanning electron microscope



Figure 11. Ion sputtering device

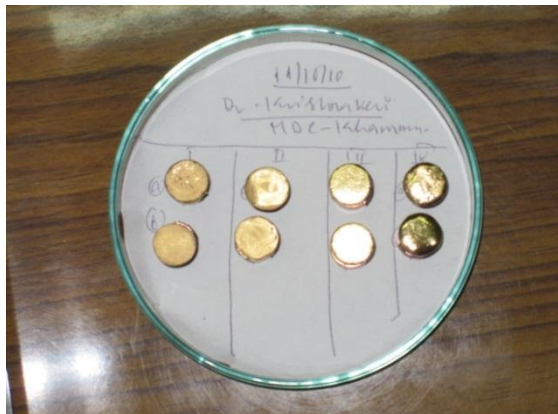
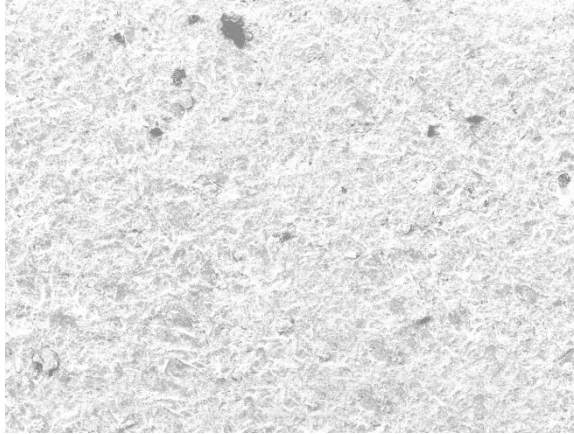


Figure 12. Ion sputtering for sem studies



Figure 13. Loading of the sample specimen into the scanning electron microscope

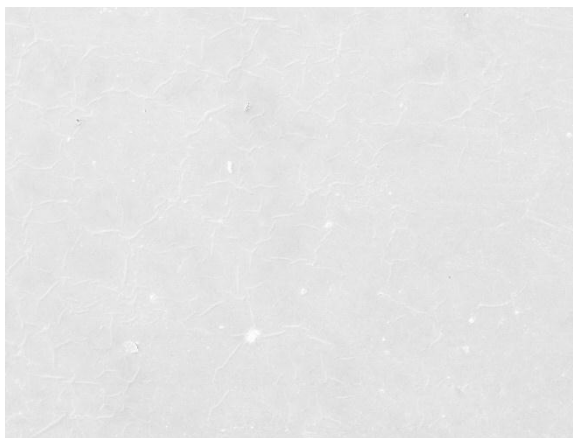
**Results**



Group IAs fired sample surface 100 X magnification



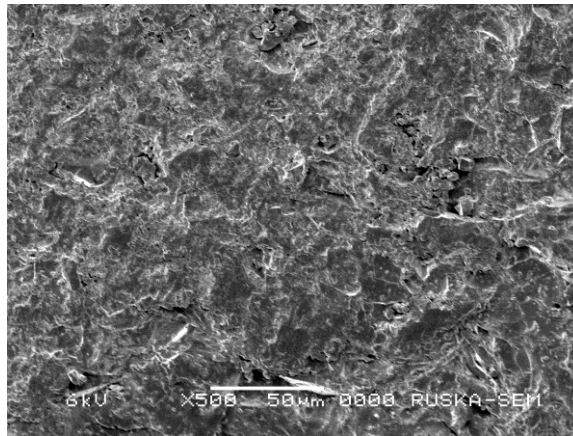
Group II diamond polished sample surface 100 X magnification



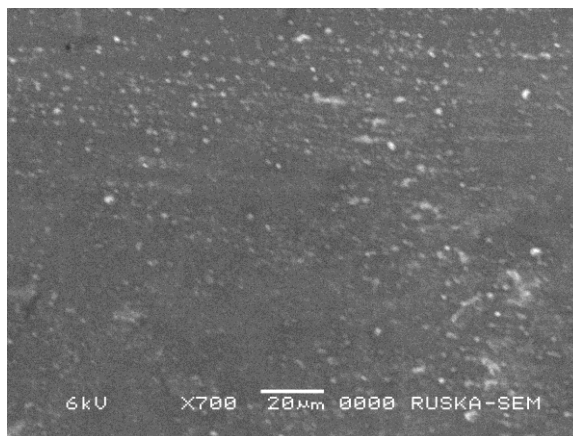
Group III selfglazed sample surface 100 X magnification



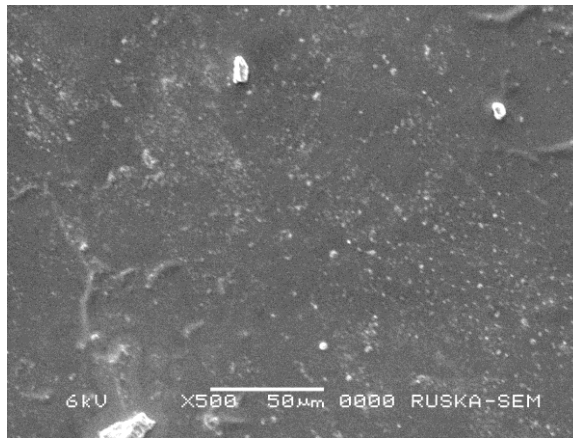
Group IV Over Glazed sample surface 100 X magnification



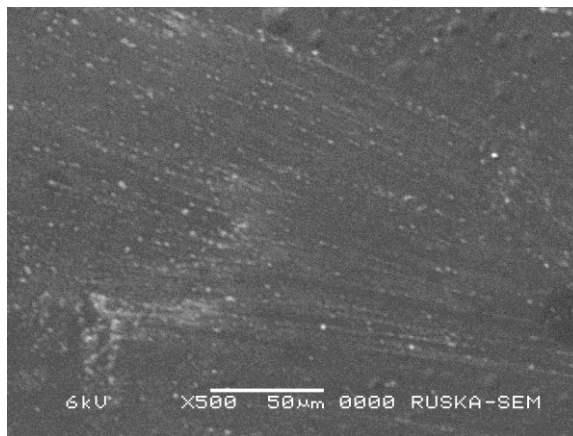
Group I As fired sample surface of porcelain 500 X magnification SEM



Group II Diamond polished sample surface of porcelain SEM 700 X magnification



Group III Self Glazed sample surface of porcelain SEM 500 X magnification



Group IV Over Glazed sample surface of porcelain SEM 500 X magnification