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# The Microstructure of MgO Refractory Brick via Backscatter Electron Imaging

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Magnesia (MgO) refractory brick consists of chromite ($Cr_2O_3$) and hematite ($Fe_2O_3$) ore that is mixed with magnesia and fired (or burned) at temperatures in the range of 1700 -1800 $^0$C. The silica ($SiO_2$), and lime (CaO) contents are controlled by the amounts contained in the specific ores used. The microstructures have been observed [1][2] to exhibit bonding between the larger ore grains by both silicate layers and by direct bonding. Spinel precipitates have been observed to occur within the MgO as a result of interdiffusion of both Cr and Fe into the MgO. [3][4]

All of these features of the microstructure of magnesia brick, as well as the porosity and cracking patterns are revealed by a novel technique used to prepare the brick for examination with the SEM. This technique involves impregnating samples with a liquid Bi-Sn alloy under pressure to fill the open porosity and then cooling the impregnated samples to solidify the Bi-Sn alloy while maintaining the pressure. Impregnated samples can then be mechanically polished using standard grinding and fine polishing techniques that involve finishing with diamond paste. Samples prepared using this method do not show any pull-outs or damage, and they may be examined directly in the SEM without coating. Another advantage of the metal impregnation technique is that samples may be argon-ion etched to reveal the finer details of the spinal precipitates that occur within the MgO grains.

The microstructure of a typical magnesia brick is illustrated by the backscatter electron images provided in Figures 1-4. Fig. 1 provides a low magnification backscatter image showing the ore grains and the porosity, which are readily observed from their atomic number contrast. Fig. 2 shows an enlargement from the area marked in Fig. 1, which illustrates a hematite ore particle that exhibits direct bonding to the MgO phase surrounding it. Fig. 3 shows the porosity and cracking patterns that are filled with Bi-Sn, and also a chromite ore particle that exhibits direct bonding to the MgO. An enlargement of the details of the interface between the $Cr_2O_3$ and the MgO is provided in Fig.5. Also shown in Fig. 3 are $SiO_2$ islands (marked by white arrow) that contribute to the bonding of MgO particles. Fig. 4 provides a higher magnification view of an $SiO_2$ layer between magnesia grains. The magnesia grains shown in Fig. 4 can be observed to contain spinel precipitates that were formed because of interdiffusion of Fe and/or Cr into the MgO. These precipitates are illustrated at high magnification in Fig. 6, where two different morphologies can be observed. The star shaped morphology (lower right) is a result of Fe interdiffusion, and the bead shaped morphology (upper left) is a result of Cr interdiffusion. These fine precipitates could only be observed after argon-ion etching of the polished sample.

## References

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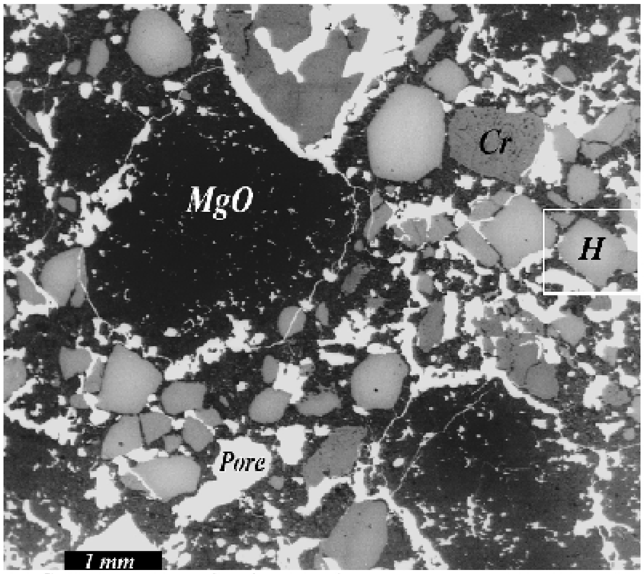


*FIG. 1 Low Magnication Backscatter Image / Cr=Chromite*

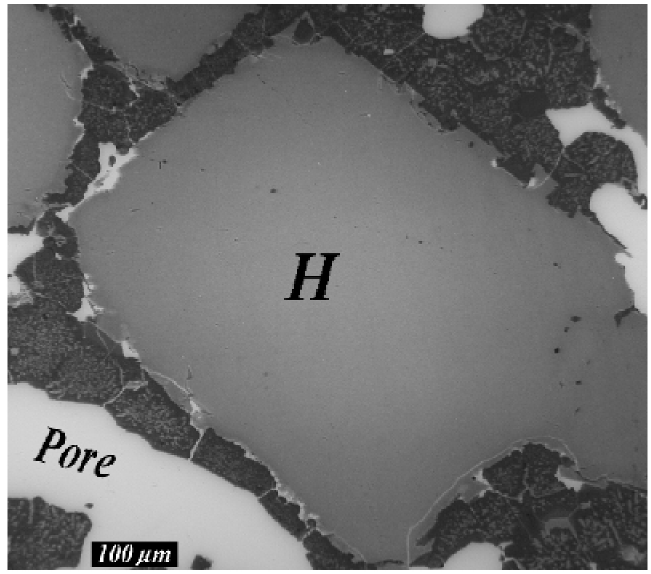


*FIG. 2 Enlargement from FIG. 1. H = Hematite*

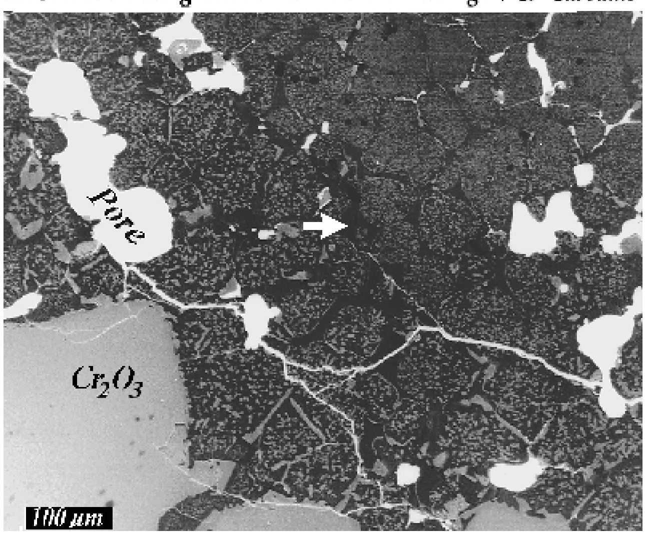


*FIG. 3 Chromite interface / Pores / $SiO_2$ @ Arrow.*

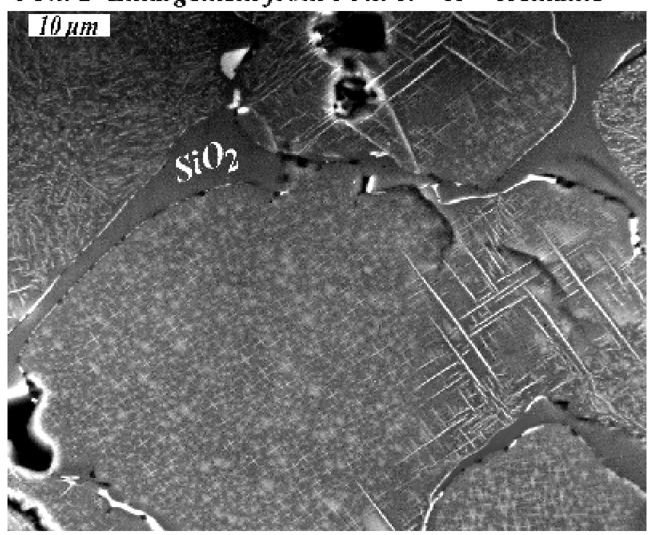


*FIG. 4 $SiO_2$ Bonding Layer & Spinel Precipitates*

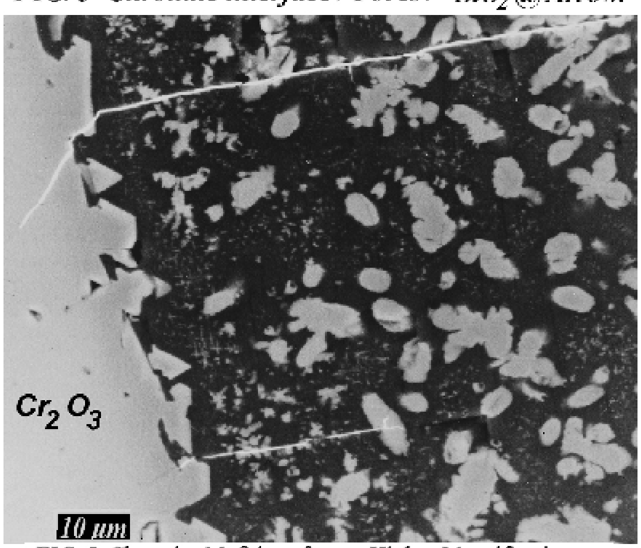


*FIG. 5 Chromite-MgO interface at Higher Magnification.*

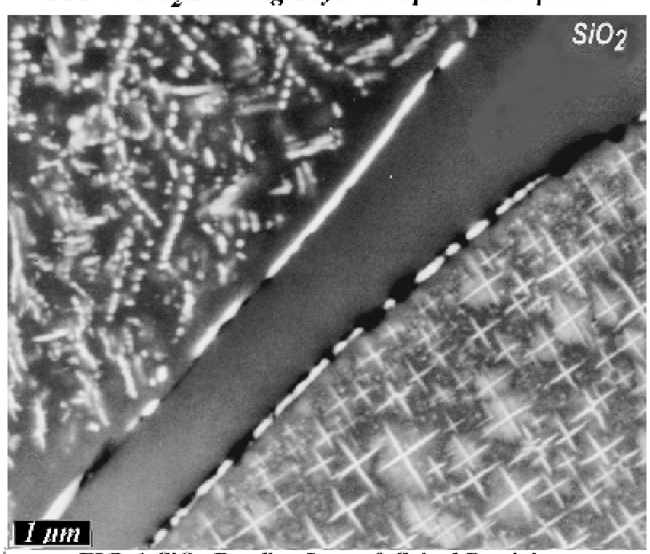


*FIG. 6 $SiO_2$ Bonding Layer & Spinel Precipitates.*

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