The Effect of Different Oxides on the Mechanical and Thermal Conductivity Properties in Thermally conductive Adhesives

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Abstract

Thermal conductive adhesives are used for use in electrical boards and IC cooling and for attaching heat sinks or electric lamps. The purpose of this article is the study on the effect of Al_2O_3, SiO_2, MgO, ZnO, and CaO as additives on the thermal conductivity and lap-shear properties of composites containing Epoxy as binder and these oxides as filler. The based conductive adhesive that is used consists of epoxy resin as a binder and some nano oxides as filler. Characterization was performed by SEM, XRD, thermal conductivity, and Lap-shear tests. The results show that alumina has the least lap-shear strength; however, it has the highest thermal conductivity. While, adhesives containing SiO_2 have the highest value of lap-shear strength and the least value in thermal conductivity. It was specified that these fillers double the thermal conductivity without changing the electrical conductivity. Since the thermal conductivity parameter is more important than the strength of the adhesive, we can say that epoxy alumina adhesives can be used as suitable adhesives for use in the industry.

Experimental method

Materials

Two-component epoxy adhesive with a volumetric mass of 1.2 g/cm^3 was used. In this work different powders such as alumina, fly-ash and industrial graphite were used to mix with epoxy and manufacture the composite. The thermal conductivity (to achieve thermal conductivity coefficient), lap shear and SEM tests were performed for characterization.

Analyses

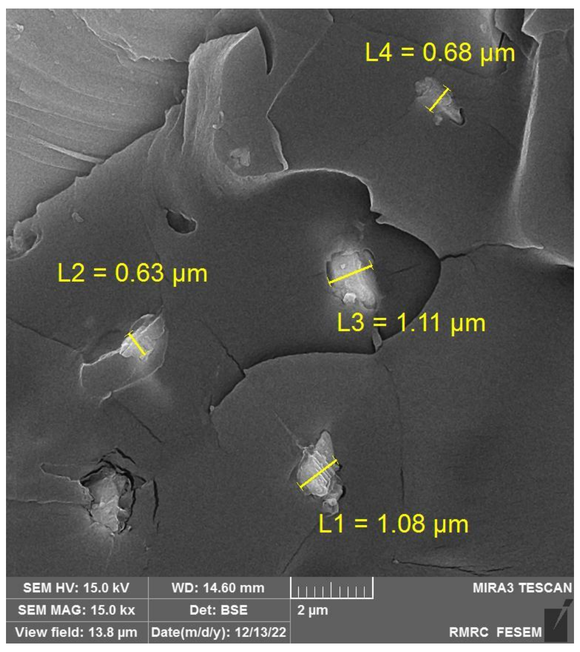
Lap-shear test

To measure the apparent shear strength of the adhesive in the butt joint, the milk lap test according to the ASTM D 1002 standard is used. To perform this test, 316L stainless steel sheet with dimensions of 101.6 × 25.4 × 32 mm was used. After cutting the samples, the part of the sheet that is supposed to be coated with glue is surface cleaned. They are first sanded with 100 to 600 grit and then washed with alcohol. An area measuring 12.7 × 4.25 mm2 from the polished edge of the sheet is covered with glue. Tensile test was done by Instron 8802 machine in Shahrood University of Technology.

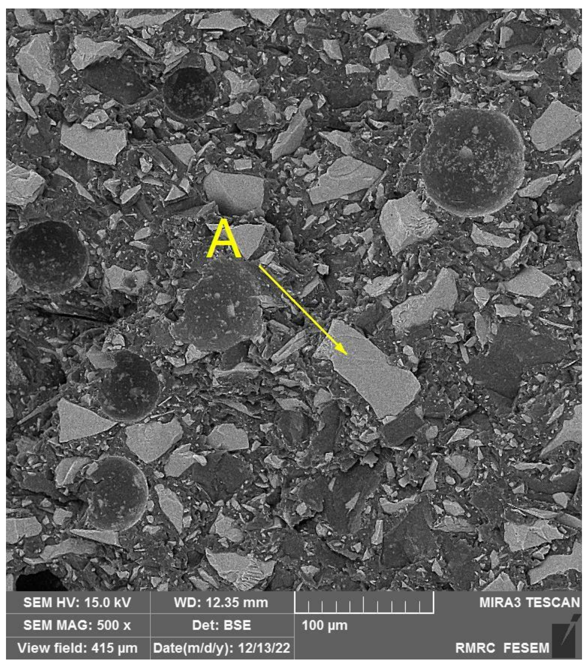
Thermal conductivity

The thermal conductivity coefficient of the sample was measured by double probe method according to ISO/IEC17025 standard and with an accuracy of 0.1 W/m.K.

Results and discusions



Epoxy containing 20 wt.% SiO_2



Epoxy containing 40 wt.% SiO_2

Fig. 1 SEM images

In Fig.1, it can be seen that there is not a strong bond between oxide powder and the epoxy resin.

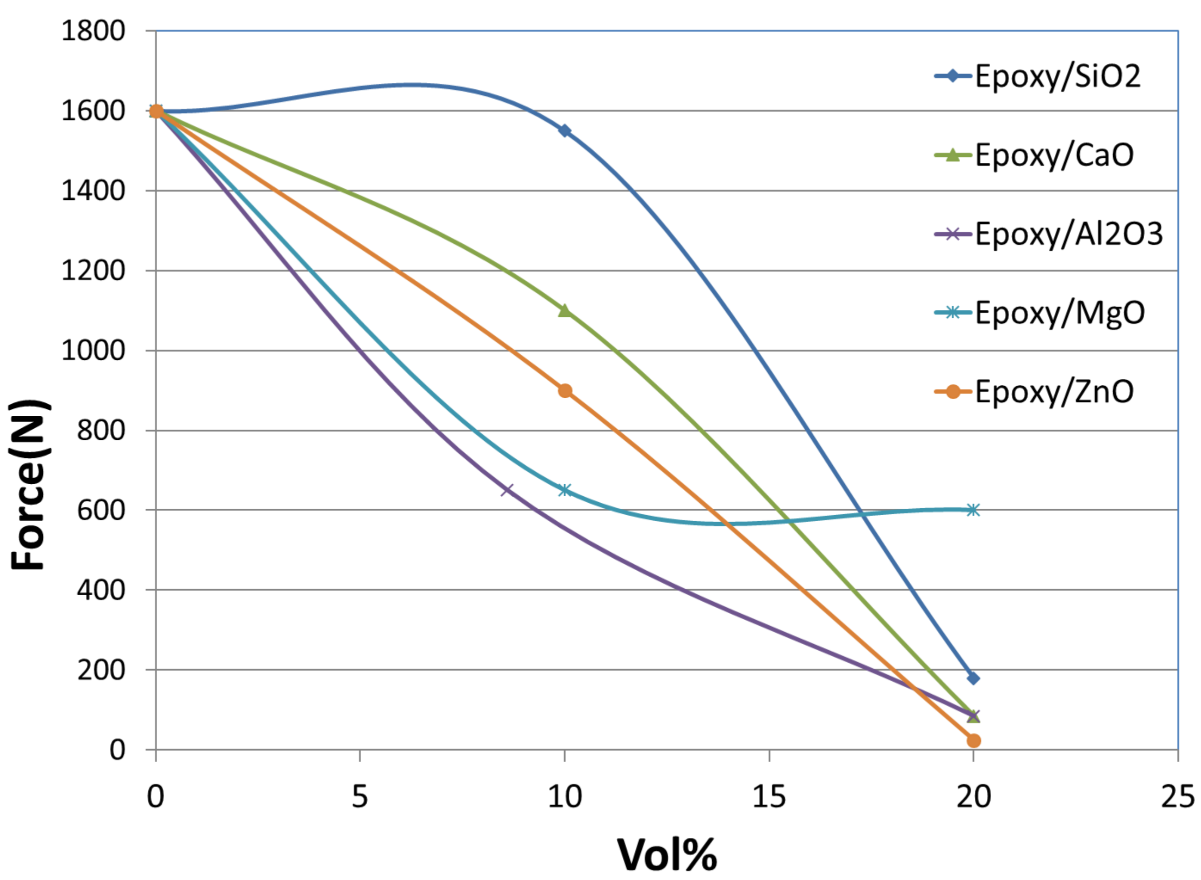


Fig.2. Lap-shear result

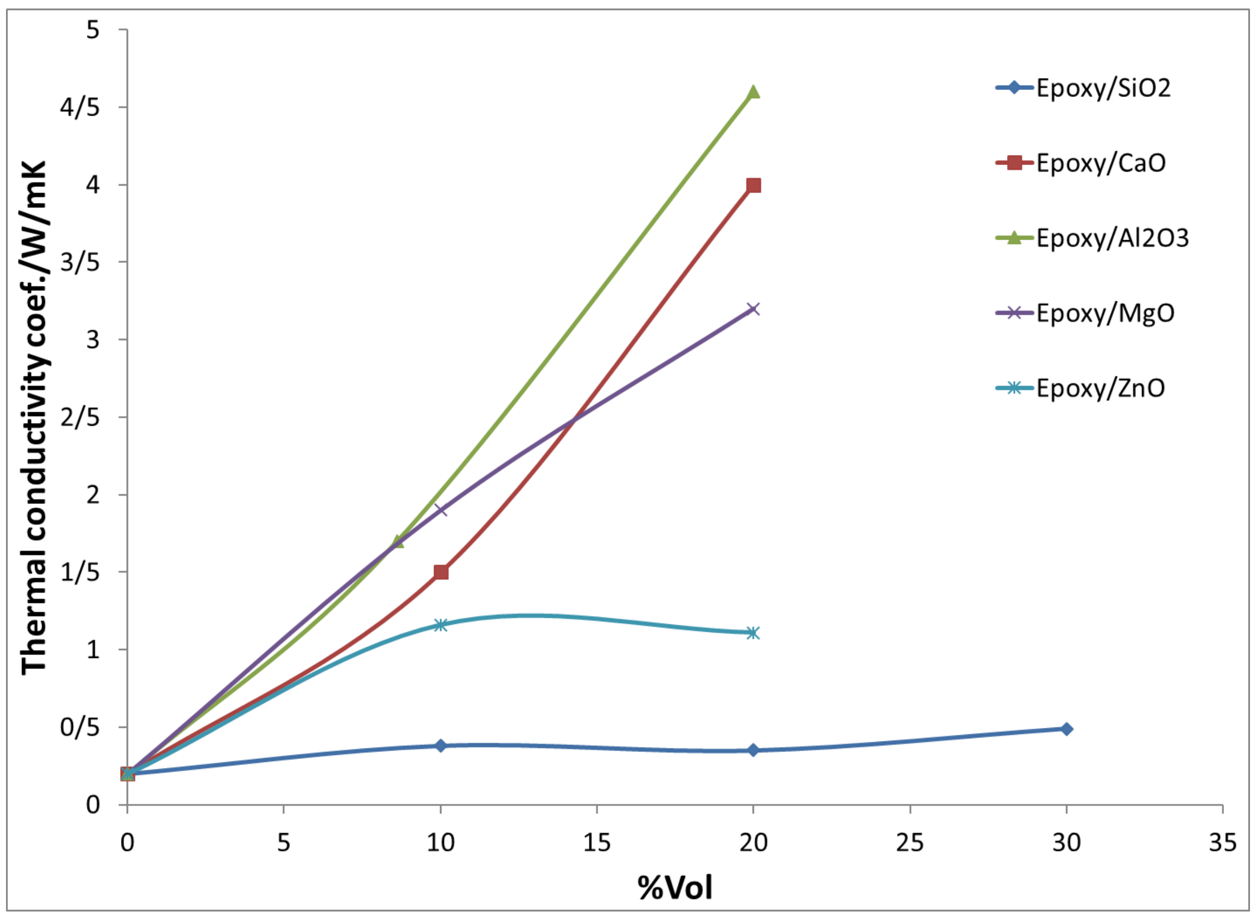


Fig.3. The result of thermal conductivity

Conclusions

In this research, different fillers were used in epoxy to obtain a thermally conductive adhesive. The results of shear strength showed that composites made of all powders decrease in shear strength when embedded in epoxy. The reason is that there is no covalent or ionic bond between the powder and the substrate, which means that the more powder we add to the composite, the result of our shear strength decreases.

The best shear strength among the samples was observed in SiO_2 and the lowest in alumina (Al_2O_3). But in terms of thermal conductivity, the samples containing alumina had much higher conductivity than the silica samples. Because in the production of thermal conductive adhesives, the thermal conductivity coefficient parameter is more important, so the composite containing 20% alumina is the best example.

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