



# Electrical properties of selected types of glass as candidates for the manufacture of metal-glass structures by melt extrusion



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This work reports on selected electrical, elemental and microscopic studies of glass samples used as a substrates for 3D printing of metal (Cu) wires.

## Introduction:

Glass is highly valued for its chemical, mechanical, and optical properties, as well as its thermal stability and insulating capabilities, making it essential in technology and electronics. This paper presents the research results obtained during the course of a project aimed at developing an innovative material concept for electronic applications, based on copper as a highly conductive material and glass as an insulating one, produced by the melt extrusion process. An important issue studied in the project is the question of achieving good adhesion of printed copper with glass. Therefore, in order to improve the adhesion, glass with a modified composition is used, which, however, affects the electrical properties of the glass itself.

## Results:

Electrical resistivity was determined using a Keithley electrometer (6517A) with a special own-build measurement attachment. The results of the performed tests are summarized in Tab. 1 and in Fig. 1.

Fig. 2 shows an exemplary copper dot deposited by melt extrusion on the surface of borosilicate glass and after separation from the glass. The figure also shows the LIBS analysis of the copper-glass interface.

## Summary:

Performed measurements show that doping of the glass results in a reduction of the material's resistivity by one to two orders of magnitude. Microscopic images of the bottom part of the copper ball after extraction from the glass substrate (Fig.2) clearly show that the copper was very strongly bonded to the substrate. Attempting to remove the copper ball from the substrate resulted in tearing out part of the glass substrate, while the glass itself still remained bounded in the contact area with the copper dot.

Tab.1. Selected properties of investigated glass samples

Glass sample	Composition	Thickness (mm)	Electrical resistivity ( $\Omega\text{cm}$ )
Silica glass	Si	0.49	$(1.035 \pm 0.096) \cdot 10^{15}$
Tempered glass	Na, Mg, Al, Si, K	0.34	$(3.701 \pm 0.142) \cdot 10^{14}$
Window glass	Na, Mg, Al, Si, Ca	1.87	$(9.856 \pm 0.142) \cdot 10^{13}$

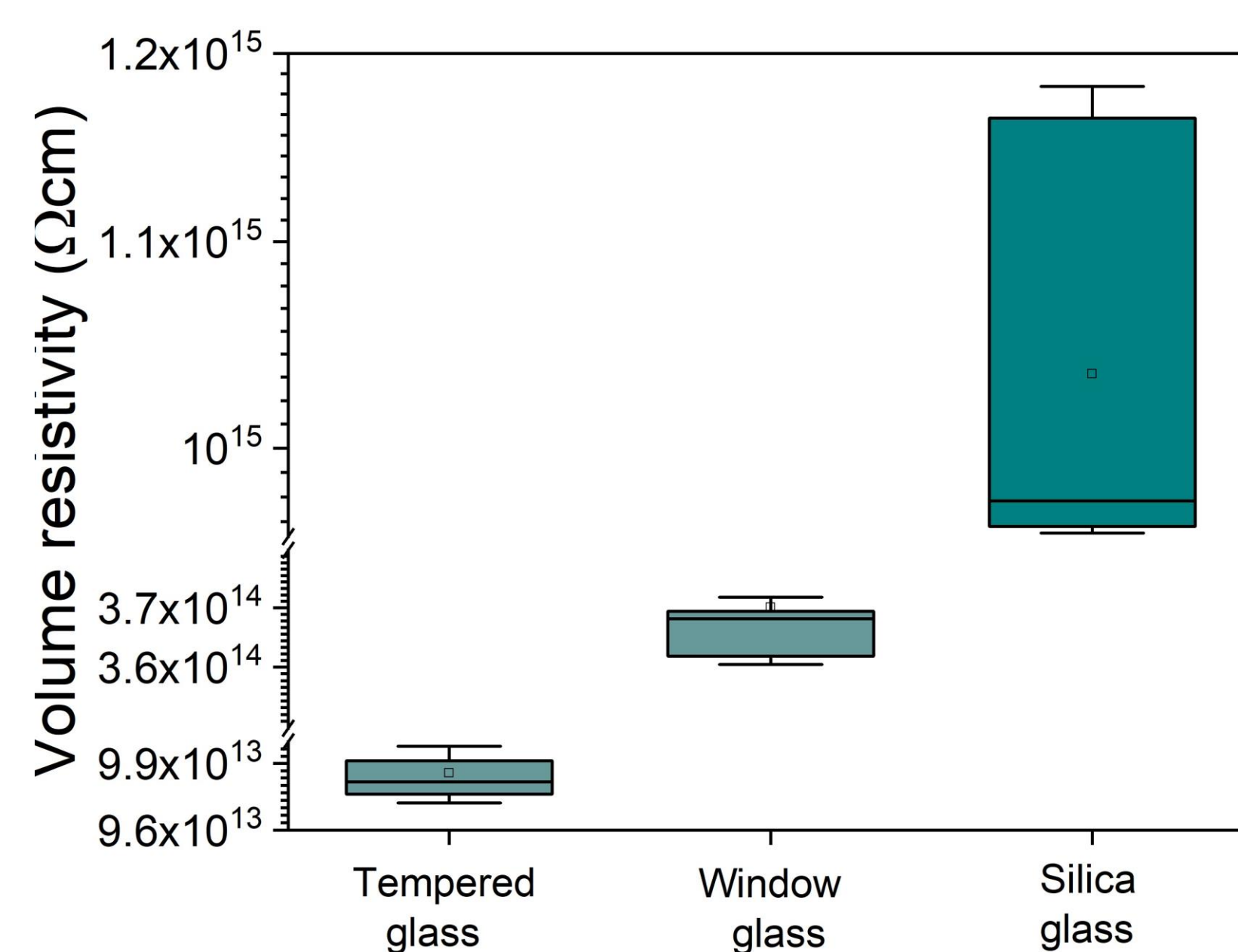


Fig. 1. Results of electrical resistivity measurements of selected glass test samples

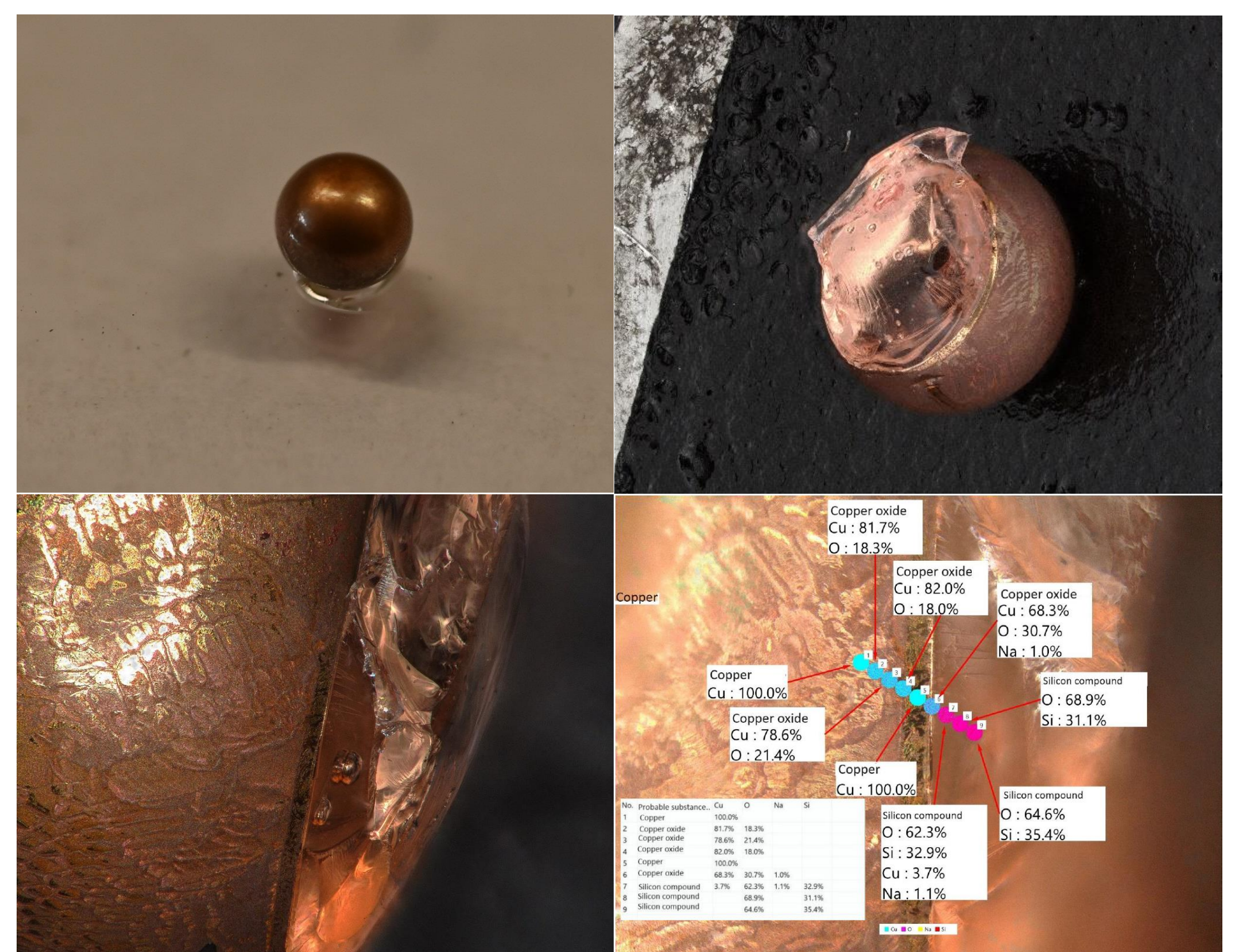
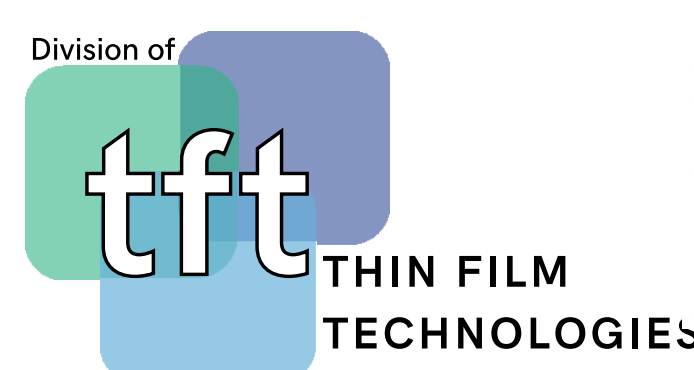


Fig. 2. Series of images of Cu dot deposited by melt extrusion on glass and after separation from glass and LIBS results of the Cu-glass interface

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