| ESRF | **Experiment title:** Structure and transport properties on Thick Film Resistors (TFRs) | **Experiment number:** HE-515 |
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## Report:

Thick film resistors (TFRs) play a relevant role in hybrid microelectronics and sensors. From a foundamental point of view they are an axcellent example of nanostructured systems with distinctive electrical characteristics in comparison with those of their "parent" components. Till now does not exist a satisfactory model for their electrical transport. The most used resistors are composed of binary Ru oxides ($RuO_2$) and high-lead silicate glass deposited on $Al_2O_3$ substrate

This experiments has been performed with the aim to investigate the effect played by different preparation methods on the local structure of Pb and Ru and relate it to the TFR properties. $RuO_2$ based TFRs were prepared acting on the composition, substrate and firing temperature. XAFS experiment on real TFR can be complicated due to the low Ru content, that requires fluorescence data acquisition geometry, and sample inhomogeneity. So a large number of TFR were "printed" for each composition then the samples were scaped from substrate, the powders were mixed with cellulose matrix and pressed to obtain pellets. In such a way we were able to obtain very homogeneous samples to measure high quality EXAFS spectra in transmission geometry (fig. 1) at the Ru K (22.117 KeV) and Pb $L_{III}$ (13.055 KeV) edges.

4 samples of different composition (A, B, C, D) $\times$ 8 temperatures (RT, 450, 700, 750, 800, 850, 900, 950 and 1000 K) $\times$ 2 edges ( Ru K and Pb $L_{III}$ ) = 64 EXAFS spectra were recorded at 80°K to reduce the effects of thermal disorder on the EXAFS oscillations.

The four kind of samples differed as concerning their substrate, glass type and vehicle used for printing. Samples A, C and D were deposited on $Al_2O_3$ while the B samples on a BeO substrate. For the samples A, B, D a glass rich in PbO and poor in $Al_2O_3$ was used while the samples C were prepared using a glass with an high content of $Al_2O_3$. Finally the D samples differed from the others as concerning the vehicle employed for printing, water instead of the standard organic vehicle (ethil-cellulose in $\alpha$-terphinol).

Only minor differences have been observed in the four kinds of samples revealing a weak influence of substrate, $Al_2O_3$ content in glass and vehicle on the $RuO_2$ short-range order. A more accurate data analysis, based on multiple scattering approach, is in progress to quantify better these effects.
On the contrary samples fired at different temperatures show different EXAFS amplitude with a clear trend, the same whatever the substrate, glass and vehicle were. In fig.1a EXAFS oscillations for 4 different firing temperatures ($T_f$) are shown. Their Fourier Transformer exhibits an evident increasing amplitude rising $T_f$. This trend can be connected with a sintering of the $RuO_2$ grains, giving explanation of the observed increasing TFRs' resistivity versus $T_f$.
As concerning Pb K-edge a larger effect was observed: the EXAFS amplitude decreases and frequency shifts rising $T_f$ (see fig.1b), giving evidence of great structural change in glass matrix.

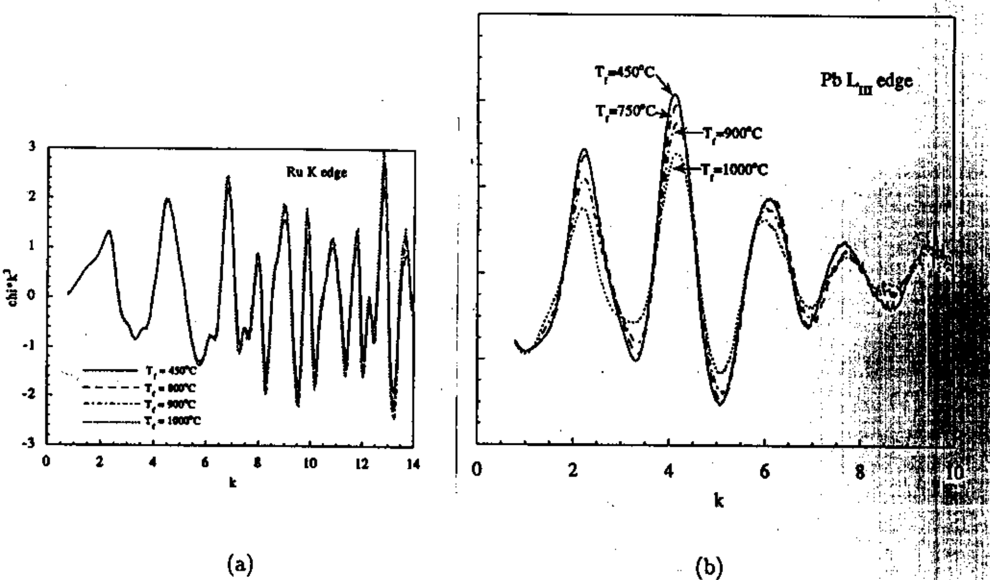


Fig.1 EXAFS oscillations at the Ru K-edge (a) and at the Pb $L_{III}$-edge (b) for some samples fired at different temperatures

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