Systematic evaluation of thin electrically insulating layers on common engineering materials

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Thin electrically insulating layers are commonly used in semiconductor technology and are therefore widely investigated when applied to Si-Wafers as substrate. Nevertheless, the use of thin insulating layers is needed in the case of typical engineering materials also, e.g. steel, alumina, titanium and its alloys. Especially in the field of metrology and thus for our institute’s main task, certain materials are given by fixed standards. Sensors made of thin conducting films, applied directly onto the component to be measured and microstructured by distinct photolithographic steps, are very promising for upcoming precision measurement technology. As stated above, many components are utilising metallic substrates and therefore, a very dense insulating layer is crucial. However, experiments have shown that the electrical insulation to the substrate is often not sufficient or fails completely and were seldom repeatable.

To determine the most important influencing factors at first, a systematic evaluation based on a screening design of experiments for the variation of ten parameters is introduced. The parameters varied were the kind of substrate material, its surface roughness, the pre-treatment steps and seven sputter process related factors (i.e. substrate to target distance, sputtertime, -power, gas-pressures, oxygen flow and bias). The experiments were done on a radiofrequency magnetron sputter system with a non-reactive process and a SiO\textsubscript{2} target for the insulating layer material. For the determination of the insulation quality itself, a layer of a Cu-Ni-alloy was deposited through a mask on top of the insulating layer. Afterwards the resistance between the substrate material and the conducting layer could be measured at seven defined areas per sample.

Analysis of the measurement results allowed the identification of the major influences on the quality of the insulation layer. For a more precise determination, further experiments with less parameter have been conducted. Based on the results, experiments were carried out with Al\textsubscript{2}O\textsubscript{3} respectively and compared to those with SiO\textsubscript{2} layers afterwards. Finally adhesion and temperature variation tests were carried out on the samples.

Keywords
electric insulation
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