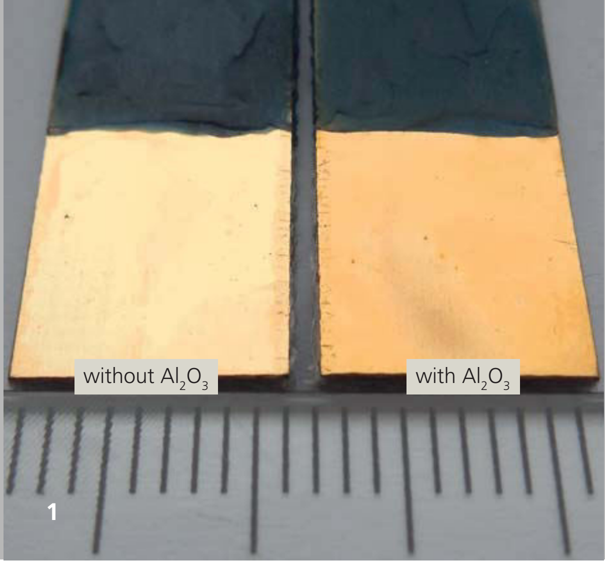

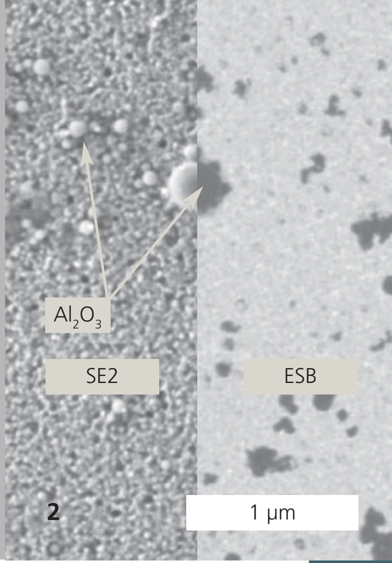

CERAMIC NANOPARTICLES FOR ELECTROLYTIC COMPOSITE COATINGS

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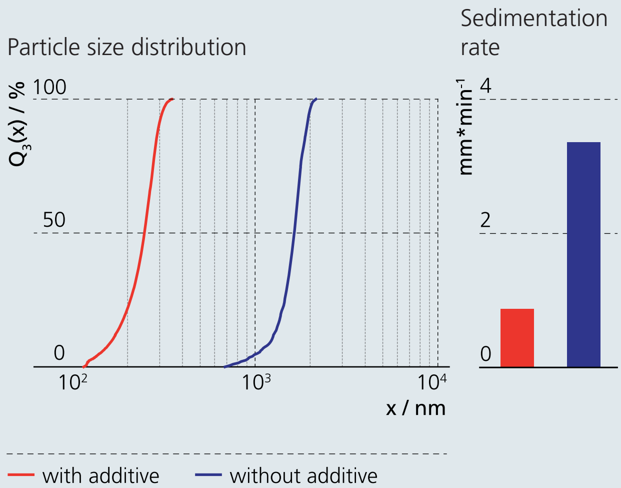
Modifying coatings with ceramic particles to create new functionalities and features is a current trend in electroplating. Nickel layers, for example reinforced with ceramic microparticles (e.g. B_4C), are already well established. The hardness and wear resistance is increased. Using submicron- and nanoscale particles is the latest trend leading to even better mechanical properties and the application on thinner composite coatings.

Anyway, the incorporation of the particles should be homogeneous. This is highly important for a successful application of the composite coatings. Hence, the deposition rate of the metal and the particles should be constant. Two factors have to be coordinated. One important point is the prevention of agglomeration and sedimentation of the ceramic nanoparticles in the plating bath. The challenge is the high ionic conductivity of the plating bath since the electrochemical double layer of the particles is compressed. An electrostatic stabilization of the particles is impossible and agglomeration of the particles would be the consequence. Alternatively, the particle can be sterically stabilized by using organic additives, preferably not being incorporated into the composite coatings. The adjoining graph shows the successful stabilization of nanoscale Al_2O_3 particles in a gold electrolyte by using an organic additive. The equivalent diameter of the ceramic particles ($x_{50,3}$) including the additive amounts to 270 nm and excluding additive to approx.1.6 µm. It is evident that the agglomeration process is enhanced without additive. Smaller particles often represent better suspension stability and result in a slower sedimentation rate. A comparison between the sedimentation rate with and without additive is shown in the graph on the right-hand side. The additive significantly prolongates the sedimentation. This improved stability of the plating bath is of great benefit. Figure 2 illustrates a stabilized suspension used for the composite coatings.

In principle, nanoscale hard materials, such as Al_2O_3, WC and others, can be incorporated in electrolytic deposits. Gold composite coatings less than 1 µm can be prepared. The gold coatings are hard and wear resistant, which raises the lifetime and reduces the consumption of expensive precious metals in jewellery and low-voltage electrical connectors.

Particle size and sedimentation of Al_2O_3 particles in electrolytes with and without additive



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1 Gold coatings with and without Al_2O_3 nanoparticles.

2 SEM picture of Al_2O_3 nanoparticles in a gold composite coating (SE2 & ESB).

3 Gold plating bath without (l.) and with (r.) Al_2O_3.

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