Kinetics and mechanism of alloy deposition; Special consideration of formation of intermetallic compounds

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The electrochemical deposition of alloys is an established process in plating technology. Much less is known about the developing structure, the driving forces of structure formation, nucleation and growth of the electrodeposited layers. It is known from the metallurgical work about alloys, that materials with new structures (intermetallic compounds, IC´s) develop astonishing new properties. The formation of intermetallic compounds is only occasionally discussed in alloy deposition.

Brenner divided alloy plating into normal and abnormal deposition, meaning that either the more noble metal (normal deposition) or the less noble metal (abnormal deposition) deposits preferentially to the second metal. In the second case he distinguished anormalous deposition and induced deposition, the latter case meaning that a metal which cannot be deposited (the reluctant metal) will be deposited together with a more noble metal (the inducing metal). This classification is a pure phenomenological one based on the deposition properties of a combination of elements. This classification gives no information about structure and no information about properties related to structure. This is a handicap of the Brunner classification because in searching for new electrochemical alloys this classification failes.

A classification based on the structural properties had to concentrate on the structure of the alloy itself. This divides the alloys into the following groups:

- Alloys immiscible in the solid state (eutectica).
- Alloys with continuous miscibility in the solid state.
- Alloys with a miscibility gap.
- Alloys forming intermetallic compounds.

The formation of a structure depends (besides crystallographic factors) on the interaction enthalpies of the components, ΔH_{AA} and ΔH_{BB}, and between the components, ΔH_{AB}. An access to the interaction enthalpy is provided by the deposition potential of alloys. Underpotential deposition (UPD) potentials are a first approach to the free enthalpy of interaction in the alloy structure.

To take into account the other factors determining the structure, structure maps are used for alloy characterization. These maps can also bring more systematic into the description of electrochemical alloy deposition. Even for binary alloys, the large number of combinations between elements together with the variety of structures of intermetallic compounds (more then 5000), makes any proposition about possible structures and their properties difficult. In the step from binary to ternary or even more complex compositions a proposition about structures and properties is not possible, for the time being.

Similar to preparation from the melt intermetallic compounds can be formed by electrochemical deposition. The nucleation process and the growth of the intermetallic phase are again depending on the interaction enthalpy, obviously a key factor in the description of alloy plating.