

Materials Science and Engineering Master's Defense

Fractal Ag electrodeposits in Radial Programmable Metallization Cells as Physical Unclonable Functions

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abstract

Counterfeiting of goods is a widespread epidemic that is affecting the world economy. The conventional labeling techniques are proving inadequate to thwart determined counterfeiters equipped with sophisticated technologies. There is a growing need of a secure labeling that is easy to manufacture and analyze but extremely difficult to copy. Programmable metallization cell technology operates on a principle of controllable reduction of a metal ions to an electrodeposit in a solid electrolyte by application of bias. The nature of metallic electrodeposit is unique for each instance of growth, moreover it has a treelike, bifurcating fractal structure with high information capacity. These qualities of the electrodeposit can be exploited to use it as a physical unclonable function. The secure labels made from the electrodeposits grown in radial structure can provide enhanced authentication and protection from counterfeiting and tampering.

So far only microscale radial structures and electrodeposits have been fabricated which limits their use to labeling only high value items due to high cost associated with their fabrication and analysis. Therefore, there's a need for a simple recipe for fabrication of macroscale structure that does not need sophisticated lithography tools and cleanroom environment. Moreover, the growth kinetics and material characteristics of such macroscale electrodeposits need to be investigated. In this thesis, a recipe for fabrication of centimeter scale radial structure for growing Ag electrodeposits using simple fabrication techniques was proposed. Fractal analysis of an electrodeposit suggested information capacity of 1.27×10^{19} . The kinetics of growth were investigated by electrical characterization of the full cell and only solid electrolyte at different temperatures. It was found that mass transport of ions is the rate limiting process in the growth. Materials and optical characterization techniques revealed that the subtle relief like structure and consequently distinct optical response of the electrodeposit provides an added layer of security. Thus, the enormous information capacity, ease of fabrication and simplicity of analysis make macroscale fractal electrodeposits grown in radial programmable metallization cells excellent candidates for application as physical unclonable functions.

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