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3-D arrays of bio-nanocomposite materials from aqueous chemical growth

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A novel concept based on a general thermodynamic model of nucleation and growth monitoring by chemical and electrostatic control of the water-oxide interfacial tension along with an aqueous thin film growth technique have been developed to fabricate very large 3-D arrays of crystalline metal oxides onto various substrates at mild temperatures[1]. The goal of such research is to design at low-cost a new generation of functional *purpose-built* metal oxide materials at nano-, meso- and micro-scale with controlled particle size, morphology and orientation from the thermohydrolysis of metal cations in aqueous solutions at mild temperatures. Their controlled heteronucleation onto various substrates leads to large scale and economical fabrication of advanced metal oxide nanomaterials without template, surfactant, applied field, or undercoating. Such well-designed materials are modeled, designed, and fabricated to optimize current devices[2], to produce novel nanodevices as well as model systems to reach better fundamental understandings of the structural and physical properties of nanomaterials[3].

Recently, such growth concept and well-designed materials have been utilized for the fabrication of bio-nanocomposite materials. Indeed, by careful selection of metal oxides and thin film texture (i.e. porous, compact, highly oriented etc) and by controlling the surface charge at the water-oxide interface, novel conformations of bio-active molecules such as amino acids, peptides and proteins can be created. Such approach has been conducted for instance on antimicrobial peptides self assembled onto transition metal oxide nanostructures to fabricate innovative and functional nano to micro biosensors.

Figure 1 shows the outcome of such strategy. The self-assembly process of bola-amphiphiles antimicrobial peptides onto substrates such as Si wafers or mica leads to anisotropic (double-strand) type of conformation. However, when such bio-active compounds is allowed to self-assemble onto designed metal oxides 3-D arrays and thin films grown by aqueous chemical growth, novel conformations are obtained showing very high specific surface area and porosity in accordance with the requirements for sensors and actuators materials[4].

Patterning, assembly and integration of bio-active molecules with 1-D nanomaterials as functional 3-D network is an important challenge scientists have to face to develop future practical bio-nanodevices. Non-lithographic fabrication of large patterned 3-D arrays of low-cost bio-nanocomposites is achievable with the aqueous chemical growth technique and is currently under scrutiny in our laboratories.

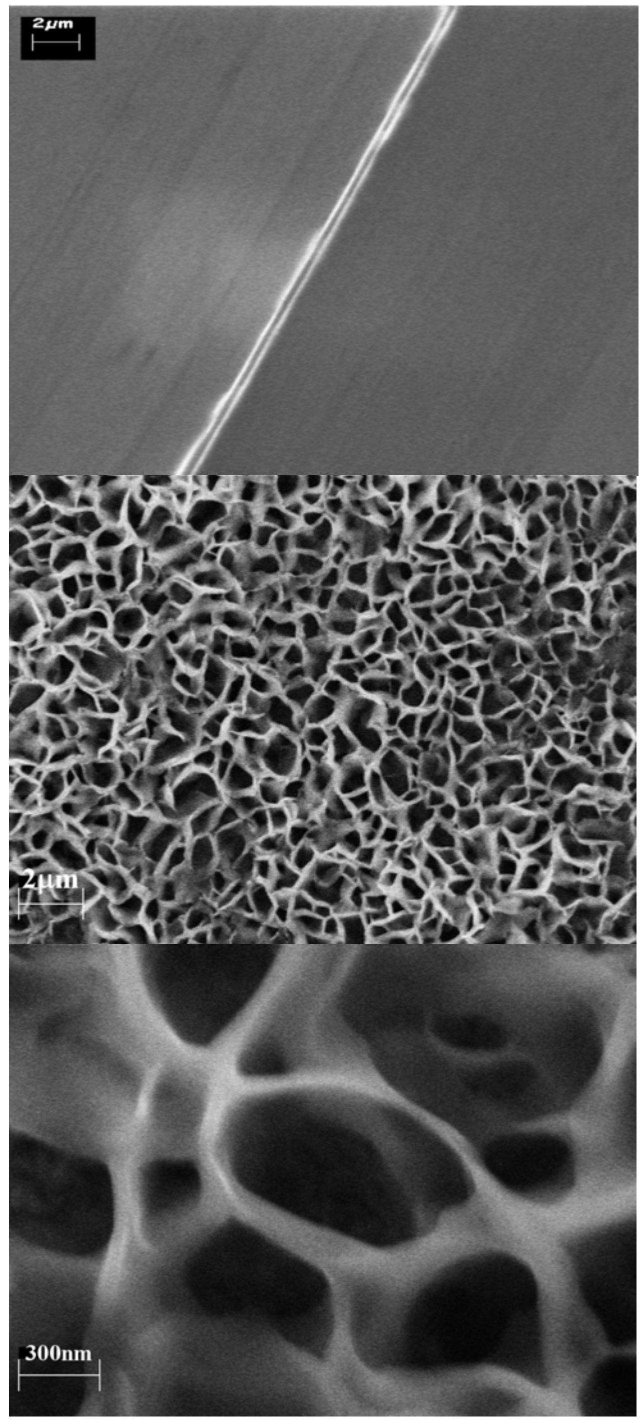

Fig. 1) Field-emission gun scanning electron microscope (FEG-SEM) images of antimicrobial peptides self-assembled onto Si wafer substrates (top) and onto designed metal oxide nanomaterials grown by aqueous chemical growth onto various substrates (middle). The bottom image shows a high resolution picture of the nano-biocomposite materials.

References

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