

SUPERCRITICAL ROUTE FOR MATERIALS SYNTHESIS

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In this lecture, first, the specific features of supercritical water reactions are summarized with explaining some experimental results of biomass conversion, chemical recycle of waste plastics, organic synthesis, heavy oil conversion and nanoparticle synthesis. Commercialization of these processes is also introduced. Regarding the new materials synthesis, recent results of supercritical method will be introduced: Variety of composite materials has been developed so far, but in many cases trade-off of the functions are of important issues: fabrication becomes difficult due to the significant increase of viscosity, and transparency of the polymer is sacrificed. To overcome the trade off, control of the nano-interface is the key, but nanoparticles are easily aggregated in polymer matrix because of the higher surface energy of NPs, and thus it has been considered a difficult task. Organic functionalization of inorganic nanoparticles is required to have higher affinity between NPs and polymers. The organic modification, NPs should be dispersed in an organic solvent with high concentration, which is difficult. For fabricating multi-functional materials, we proposed a new method to synthesize organic modified nanoparticles (NPs) in supercritical water (Fig.1). Since the organic molecules and metal salt aqueous solutions are miscible under the



Figure 1 Flow reactor apparatus for supercritical hydrothermal synthesis (ITEC Co., LTD, Japan).

supercritical state, and water molecule works as an acid/base catalyst for the reactions, organic-inorganic conjugate nanoparticles can be synthesized under the condition (Fig.2). The hybrid NPs show high affinity with the organic solvent or the polymer matrix (Fig.3). This method enables self-assembly of NPs through the organic linkers to form crystal of NPs as shown in Fig.4. This controllable functionalization of NPs leads to fabricate the organic

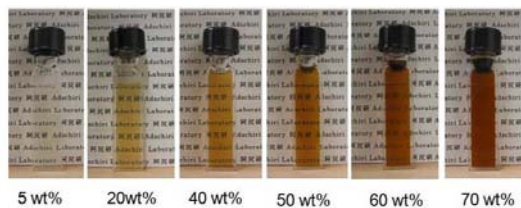


Figure 3. Dispersion of decanoic-acid-capped ceria NPs dispersed in cyclohexane

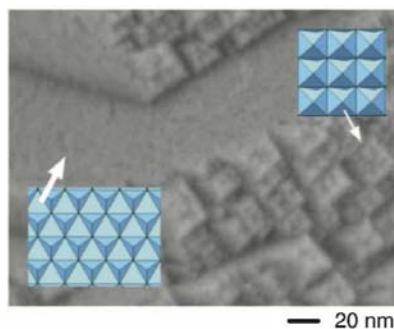


Figure 4 Nanoassembled 3D structure comprising primary octahedral CeO_2 nanocrystal

inorganic hybrid nanomaterials with the compatible (trade-off) functions. Hybrid polymer with high loading of BN achieved extremely high heat transfer coefficient (40 W/m/K) in vertical direction to the sheet with maintaining the flexibility (Fig.5). In case of Al_2O_3 loaded resin, due to the organic surface modification of NPs, more than 80 vol % of high loading could be achieved with keeping the fluidity (low viscosity), which enables transferring this soft-feramics to the package of semiconductor device without the damage of electric circuit (Fig.5).

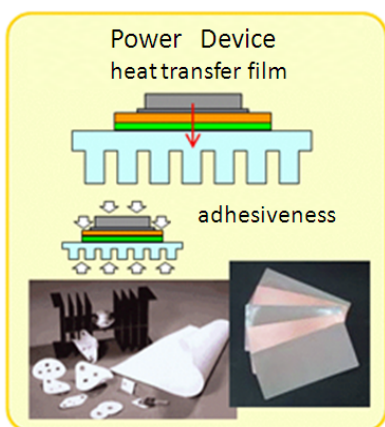


Figure 5 Flexible heat transfer sheet: Thermal conductivity: 40W/m/K

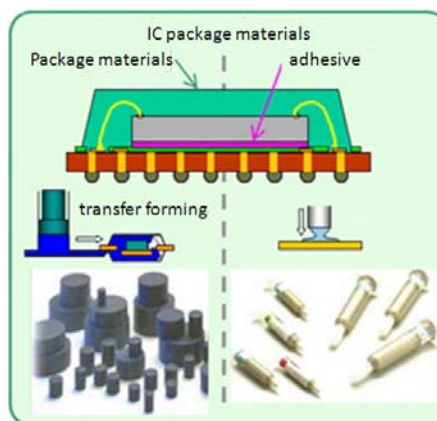


Figure 6 High heat transfer- low viscosity package materials