In book "Polymer Surface modification and polymer coatings by dry process technologies", 2005: pp.85-109, ISBN: 81-7736-276-3 Ed. Satoru Iwamori (Research Signpost, Kerala, India).

Polymer-metal nanocomposite thin film prepared by co-evaporation in a vacuum

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ABSTRACT

This paper presents a review on the deposition of polymer composite films by co-evaporation technique. In particular, the structure and properties of polytetrafluoroethylene (PTFE) and polyparaphenylene sulphide (PPS) films, containing gold (Au) and dye nanoclusters are discussed. For the first time, multi-component films, consisting of Au nanoparticles and organic molecules (dye or thiol), dispersed in the PTFE matrix, were fabricated. Films were obtained using two methods: a) an *in situ* method - the simultaneous evaporation of Au, dye and PTFE; and b) an *ex situ* method based on a post-deposition immersion of a Au-PTFE film in a solution of thiol.

The cluster formation process was studied *in situ* by optical spectroscopy. A low temperature plasma was used to modify film structure. Film characterization was achieved by X-ray photoelectron spectroscopy (XPS), transmission electron microscopy (TEM), atomic force microscopy (AFM) and ellipsometry. Early in the Au-PTFE film growth a plasmon band at 460-480 nm appeared, but as film thickness increased it shifted toward 560 nm. The Au cluster diameters were in the 3-7 nm range. A plasma treatment of the vapors led to formation of smaller, but more aggregated clusters. Both modelling and ellipsometry data show, that the portion of clusters are spheroids. During the Au-PPS film deposition, two stepped growth mechanisms were encountered. Early in the film growth a plasmon band appeared at 540 nm, but as thickness increases a band at 430 nm dominates. In case of PPS matrix, the influence of plasma treatment on cluster size and film morphology was larger. Without plasma treatment, a disordered mixture was deposited, while with plasma treatment large Au aggregates were formed within PPS matrix with a band at 620 nm.

The presence of a thiol on the Au nanocluster surface is shown by the plasmon resonance peak blue shift and by XPS. The thiol-treated films have increased sensibility towards hydrocarbon vapours. Au-PTFE films treatment with various thiols led to formation of materials with optical changes selective to adsorption of specific compounds.