Thermoplasmonic ITO nanoparticles' Ink for IR-enabled applications

Arianna Mazzotta
Alessio Gabbani, Marco Carlotti, Marina Ruggeri, Elvira Fantechi,
Andrea Ottomaniello, Francesco Pineider, Andrea Pucci, Virgilio Mattoli

Center for Materials Interfaces, Istituto Italiano di Tecnologia, Viale R. Piaggio 34, Pontedera 56025, Italy
The Biorobotics Institute, Scuola Superiore Sant'Anna, Viale R. Piaggio 34, Pontedera 56025, Italy
Department of Chemistry and Industrial Chemistry, University of Pisa, Via Moruzzi 13, 56124 Pisa, Italy

arianna.mazzotta@iit.it

Counterfeiting of goods is a rapidly expanding issue in our society. To date, the most common anti-counterfeiting technologies use tags that can be easily cloned, making it necessary to constantly search for novel methods that are simple to fabricate but complex to replicate. Notably, anti-counterfeiting strategies could make use of nanoparticles: compared to molecular technologies, these approaches are more complex to counterfeit since they cannot be easily reverse-engineered.
In this work we propose a thermoplasmonic transparent ink made of a colloidal dispersion of tin-doped indium-tin-oxide nanoparticles (ITO-NPs) able to generate heat by absorption of NIR radiation.
The synthesized undoped ITO-NPs (ITO-0) and 10% tin-doped ITO NPs (ITO-10) have a spherical shape and, notably, ITO-10 shows a smaller average diameter: this aspect contributes to decrease scattering and, therefore, to the increase in absorption, which is the main contribution to the conversion of photons into heat. Moreover, we observed how it is possible to tune the absorption peak by finely controlling the dopant concentration.
The functional ink made of ITO-10 can be directly printed on transparent substrates in order to obtain arbitrary patterns with fine features (in the order of 75 microns) and high thermal resolution (of about 250 microns). We printed several figures in order to characterize the printing process and the temperature dynamics. Among these, we built a demonstrator comprising a QR Code invisible to the naked eye which became visible in thermal images under NIR radiation. The high transparency of the printed ink (transmittance >99%) and the fast thermal read-out (figures appear/disappear in less than 1s) allow an effective fabrication and decryption of security labels against counterfeiting, offering a solution for low-cost, scalable production of photothermally active invisible labels. Noteworthy, tin doped adjustable functional ink can be of great practical interest toward specific and tailored sensing applications in the NIR range.

Figures

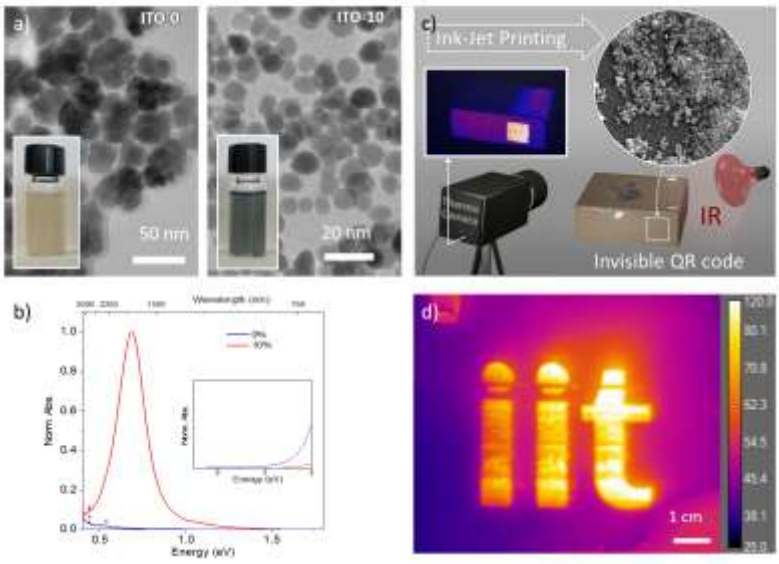

Figure 1: a) TEM pictures of tin-doped (red) and undoped (blue) ITO nanoparticles and b) their absorption spectrum; c) demonstrator of a real application for the custom ink; d) thermal image of one of the printed figures while irradiated with a NIR lamp.