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Highly Sensitive Acetylene Sensors Based on Flame-spray-made *p*-type CuO Nanoparticulate/Electrolytically Exfoliated Graphene Composites

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Abstract:

Acetylene (C_2H_2) is one of the most flammable gases, which can be dissolved in transformer oil for industrial applications and is usually monitored for condition assessment and fault diagnosis of transformers [1–3]. Thus, it's essential to fabricate metal oxide based sensor for effective C_2H_2 detection with high sensitivity and stability [4]. In this work, *p*-type flame-spray-made CuO nanoparticles was successfully produced for the first time and were loaded with 0–5 wt% *p*-type electrolytically-exfoliated graphene for C_2H_2 gas-sensing enhancement. Characterizations by X-ray analysis, Raman spectrometry, nitrogen adsorption, and electron microscopy demonstrated that high-quality multilayer graphene sheets with low oxygen content were widely distributed within nanoparticles having polycrystalline CuO phase (Fig.1). The sensing films were tested towards various gases at working temperatures ranging from 200–400°C. Gas-sensing results showed that the optimal 2 wt% graphene provided a high response of ~500 toward 1 vol% of C_2H_2 with short time factors and good recovery stabilization at 350°C (Fig.2). In addition, the graphene loading enhanced the response by more than one order of magnitude compared with that of unloaded one. The superior gas-sensing performances of CuO/graphene heterojunctions may be attributed to large specific surface area of the composite, high density of reactive sites of highly porous non-agglomerated graphene-CuO structure and high electronic conductivity of graphene, resulting in fast response and recovery behaviors. Therefore, the *p*-*p* heterojunctions of CuO/graphene based sensor is a highly interesting new candidate for fast and sensitive detection of C_2H_2 which may be useful for agricultural and industrial applications.

Keywords: Flame spray pyrolysis, Acetylene, CuO, Graphene loading, Gas sensor.

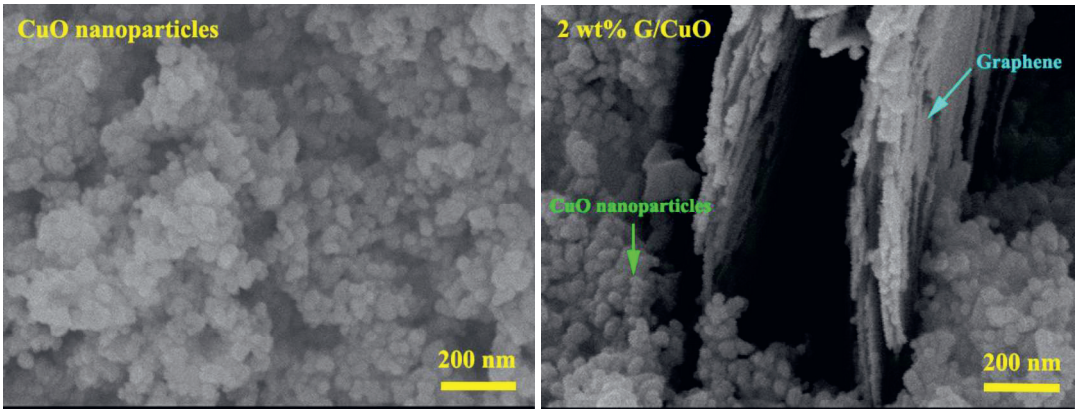

Fig.1. A typical top–view SEM image of as-prepared p-type CuO nanopartilces produced by flame spray pyrolysis for the first time (Left) and loaded with 2 wt% p-type electrolytically-exfoliated graphene (Right) at the same magnification.

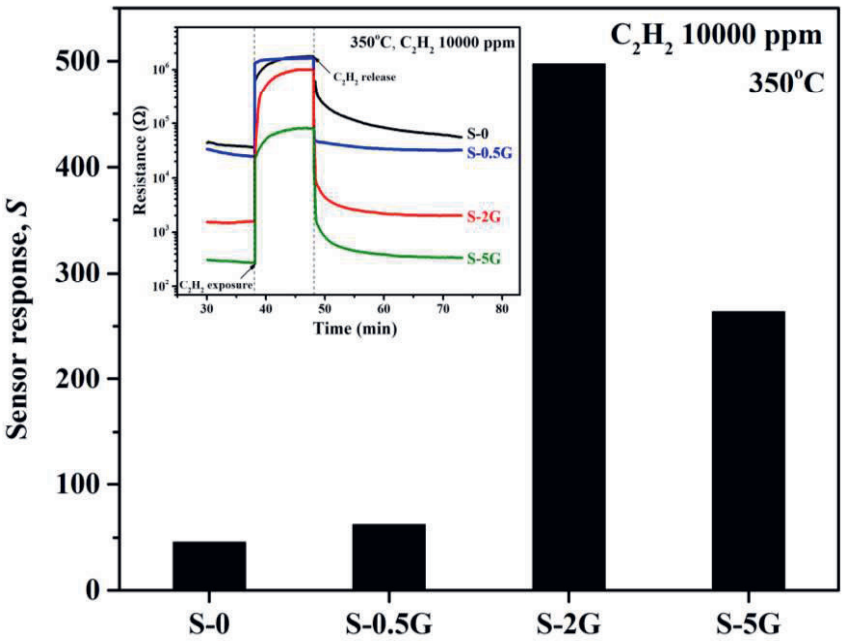

Fig. 2. The histograms of typical sensor response towards 10000 ppm (1 vol%) C_2H_2 with corresponding change in resistance (insets) of the facricated sensor based on flame-spray-made CuO nanoparticles loaded with with 0–5 wt% graphene (S–0 to S–5G) at optimal working temperature of 350˚C in dry air.

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