UNIVERSITÀ DEGLI STUDI DI MILANO

CONCORSO PUBBLICO, PER TITOLI ED ESAMI, A N. 1 POSTO DI CATEGORIA C - AREA TECNICA, TECNICO-SCIENTIFICA ED ELABORAZIONE DATI, CON RAPPORTO DI LAVORO SUBORDINATO A TEMPO INDETERMINATO PRESSO L'UNIVERSITÀ DEGLI STUDI MILANO - DIPARTIMENTO DI FISICA "ALDO PONTREMOLI", DA RISERVARE, PRIORITARIAMENTE, ALLE CATEGORIE DI CUI AL DECRETO LEGISLATIVO N. 66/2010, BANDITO CON DETERMINA N. 7678 DELL'11.5.2021, PUBBLICATO SULLA G.U. N. 42 DEL 28.5.2021 – CODICE 21570

La Commissione Giudicatrice del concorso, nominata con determina n. 10485 del 22.6.2021, composta da:

Prof. Stefano Poli	Presidente
Prof.ssa Gabriella Tedeschi	Componente
Sig. Francesco Cavaliere	Componente
Dott.ssa Ylenia Marzà	Segretaria

comunica i quesiti relativi alla prova orale:

Gruppo quesiti n.1

1. Il candidato presenti le tecniche di saldatura, in particolare quelle più utilizzate nel contesto di strumentazione scientifica.

2. Il candidato legga, traduca ed esponga il contenuto del brano estratto dall'articolo scientifico "Anomalous electrical conduction and negative temperature coefficient of resistance in nanostructured gold resistive switching films", §1, Scientific Reports, 2020 (come da allegato)

Gruppo quesiti n.2

1. Il candidato presenti le tecniche di fabbricazione sottrattiva con macchine utensili tradizionali.

2. Il candidato legga, traduca ed esponga il contenuto del brano estratto dall'articolo scientifico "Anomalous electrical conduction and negative temperature coefficient of resistance in nanostructured gold resistive switching films", §2, Scientific Reports, 2020 (come da allegato)

Milano, 09/07/2021

La Commissione

Prof. Stefano Poli - Presidente

Prof.ssa Gabriella Tedeschi - Componente

Sig. Francesco Cavaliere - Componente

Dott.ssa Ylenia Marzà - Segretaria

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Anomalous electrical conduction and negative temperature coefficient of resistance in nanostructured gold resistive switching films

M. Mirigliano[1], S. Radice[1], A. Falqui[2], A. Casu[2], F. Cavaliere[1] & P. Milani[1]✉

We report the observation of non-metallic electrical conduction, resistive switching, and a negative temperature coefficient of resistance in nanostructured gold films above the electrical percolation and in strong-coupling regime, from room down to cryogenic temperatures (24 K). Nanostructured continuous gold films are assembled by supersonic cluster beam deposition of Au aggregates formed in the gas phase. The structure of the cluster-assembled films is characterized by an extremely high density of randomly oriented crystalline nanodomains, separated by grain boundaries and with a large number of lattice defects. Our data indicates that space charge limited conduction and Coulomb blockade are at the origin of the anomalous electrical behavior. The high density of extended defects and grain boundaries causes the localization of conduction electrons over the entire investigated temperature range.

Granular metallic films (GMFs) consist of random networks of metal clusters or nanoparticles, with different size and structure, separated by a dielectric matrix (either vacuum or a non-conducting material)[1–3]. The electrical properties of GMFs are strongly dependent on the coupling between adjacent metallic units and the transition from non-metallic transport to metallic conduction has been actively studied by varying their density from very diluted (weak-coupling regime) to particle structural percolation (strong-coupling regime)[3–9]. Systems in weak-coupling regime have received particular attention in order to understand the role of defects and discontinuities in determining the non-metallic behavior, whereas systems in strong-coupling regime are reported to be ohmic with conventional transport mechanisms typical of polycrystalline metallic films[10–13].

Random networks of metallic nanowires/nanoparticles in a polymeric matrix or passivated by shell of ligands or oxide layers have gained a renewed interest for the fabrication of non-linear circuital elements such as memristors and resistive switching devices for analog computing and neuromorphic data processing[14–18]. These systems are in the weak-coupling regime and their electrical behavior is determined by the formation/destruction of conducting junctions between isolated nanoparticles conferring neuromorphic properties to the networks[14–17,19–21].

Recently we showed that granular systems in strong-coupling regime consisting of continuous cluster-assembled gold films produced by the assembling of unprotected clusters, also show resistive switching[22,23]. Their structure is characterized by the random stacking of differently shaped crystalline clusters directly connected by junctions of different cross sections with an extremely high number of defects and grain boundaries[22,23].

Here we report that continuous cluster-assembled gold films, although in strong-coupling regime, show non-metallic electrical conduction and negative Temperature Coefficient of Resistance (TCR) within 24–300 K temperature range. The observed behavior indicates that conduction mechanisms typical of insulators or highly disordered semiconductors are occurring. Remarkably, the resistive switching activity of these systems is maintained down to cryogenic temperatures.

[1]CIMAINA and Department of Physics, Università Degli Studi Di Milano, via Celoria 16, 20133 Milano, Italy. [2]NABLA Lab, Biological and Environmental Sciences and Engineering (BESE) Division, King Abdullah University of Science and Technology (KAUST), Thuwal 23955-6900, Saudi Arabia. ✉email: paolo.milani@mi.infn.it