Seminar

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Institute for Plasma Research

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Title: Cold Plasma Oxidation of Copper

Speaker: Dr. Shilpa Singh
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Date: 13th February 2026 (Friday)

Time: 10:30 AM

Venue: Seminar Hall, IPR

Abstract

The growing global energy demand has led to increased CO_2 emissions from carbon-based fuels, creating serious environmental concerns. As a result, converting CO_2 into useful fuels has become an important research goal. CuO has shown strong potential as a catalyst for CO_2 conversion. CuO can be synthesized using various methods, with thermal oxidation being the most common. However, conventional thermal oxidation requires high temperatures to obtain single-phase CuO, leading to high energy consumption. Cold plasma oxidation offers an energy-efficient alternative, enabling CuO formation at room temperature. In addition, plasma treatment can enhance catalytic performance by increasing surface area, creating defects, increasing grain boundary density, and exposing active crystal planes.

In this work, we systematically investigate the cold plasma oxidation of copper under sub-atmospheric pressure in air and oxygen environments. Copper discs were first used to evaluate the feasibility of room-temperature oxidation. Raman spectroscopy confirmed the formation of CuO, although traces of Cu_2O were also detected. SEM analysis revealed the development of oxide layers on the copper surface. The study was then extended to copper powder to examine the effects of plasma parameters, including working pressure (0.5, 1, and 2 mbar) and reaction time (10–80 minutes). X-ray diffraction and Raman spectroscopy showed that Cu_2O dominated at lower oxidation levels, while CuO became the dominant phase at higher oxidation levels. X-ray photoelectron spectroscopy confirmed the formation of CuO and indicated a high concentration of oxygen vacancies. At working pressures of 1 and 2 mbar, the CuO/Cu_2O ratio remained close to 1:1, with CuO fractions of 35.27% and 39%, respectively. The oxygen vacancy concentration was also significant, though it decreased from ~25% at 1 mbar to ~21% at 2 mbar. Morphological analysis showed that oxidation initiated at the dendritic edges of copper particles. With longer plasma exposure, island-like and poorly defined rod-like structures formed. The results are qualitatively indicative of thermal oxidation dominating cation migration (outward migration of copper) in oxides to form CuO [1] while the plasma oxidation appears to facilitate anion migration (inward migration of oxygen) [2].

Overall, this study demonstrates the successful room-temperature synthesis of CuO using cold plasma oxidation, with reaction time and working pressure playing key roles in controlling the structural and morphological evolution. However, detailed studies and characterization are required to support and validate the above hypothesis.

Ref:

[1] N. Nilium et al.; Surf. Sci. Reports 79 (2024) 100622
https://www.sciencedirect.com/science/article/pii/S0167572924000013

[2] S. Kunze et al.; Chem. Science 12 (2021) 14241-14253