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Designing ultra-radiopure, high-strength, electroformed CuCr and CuCrTi alloys, for rare event searches

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Future detecting systems for direct Dark Matter (DM) detection require ultra radiopure materials. Electroformed copper (EFCu) is the material of choice for large-scale detectors thanks to its favourable radiochemical, thermal, and electrical properties. To fulfil the unique radiopurity requirements, experiments pioneer large-scale, additive-free Cu electroformation in deep underground laboratories. This novel technique leads to extreme radiopurities with contamination below 10^{-14} grams of ^{232}Th (Thorium) and ^{238}U (Uranium) per Cu gram. However, Cu is highly ductile and of low strength, limiting its use for moving mechanical, high-pressure, and load-bearing parts. Alloying Cu with chromium (Cr) can lead to enhanced mechanical properties due to solid solution and precipitation strengthening. Moreover, small additions of titanium (Ti) can allow for improved mechanical strengthening. We investigate and address materials challenges to develop high radiopure Cu-based alloys with significantly higher strength compared to Cu. This would improve the capability for experiments such as DarkSPHERE, a large-scale fully electroformed underground spherical proportional counter operating under high pressure to probe uncharted territory in the search for DM. It is also vital for other rare event searches, including the next-generation experiment XLZD or searches for neutrinoless double β-decay.

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