Contribution ID: **30** Type: **Parallel session talk**

Ultra-Pure Nickel for Structural Components of Low-Radioactivity Instruments

Wednesday 8 October 2025 16:30 (20 minutes)

We report an evaluation of nickel produced via chemical vapor deposition (CVD) for potential use as a general structural material in future, large-scale, low-radioactivity rare-event search experiments in nuclear and particle physics. In particular, this work is focused on assessing both mechanical strength and radiopurity (i.e., concentration of primordial radionuclides ^{232}Th, ^{238}U, and ^{40}K) of CVD Ni, two critical considerations for use as a structural material in future experiments. Nickel can have tensile strengths significantly exceeding that of ultra-pure copper, a material frequently used within low-radioactivity instruments. Pull tests of the manufacturer-supplied CVD Ni showed tensile strengths of ˜600 MPa. However, initial welding tests produced welds of reduced strength (˜160-315 MPa) more similar to the strength of commercially available (annealed) Ni plate (˜370-400 MPa). This behavior may be related to the observed porosity of CVD Ni and/or thermal annealing. Material assay results determined via ICP-MS showed the bulk of the CVD Ni had concentrations of ^{232}Th, ^{238}U, and ^{nat}K on the order of ˜70 fg·g^{-1} (˜0.3 μBq·kg^{-1}), ≤100 fg·g^{-1} (≤1.24 μBq·kg^{-1}), and ˜900 pg·g^{-1} (˜27.5 μBq·kg^{-1}), respectively. In addition to bulk radiopurity results, an evaluation of radio-contaminant distribution with depth into CVD Ni is also presented. Notably the exterior surfaces of the CVD nickel showed elevated levels of these radioactive elements. New data are compared to results from SNO, the one other well documented usage of CVD Ni in a low radioactive background physics research experiment. In summary, CVD Ni presents a promising option for use as a low-radioactive structural material.

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Session Classification: RDC 7 Low-Background Detectors

Track Classification: RDC 7 Low-Background Detectors