

Superior Nickel Foam Production: Starting from Raw Materials Quality Control

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To meet the requirements of nickel-based battery producers and hybrid electric vehicle (HEV) market applications, Inco has developed Incofoam[®] nickel foam production facilities in Wales, UK and China for manufacturing of superior quality nickel foams using both carbonyl chemical vapor deposition (CVD) and electroplating technologies, with a combined annual capacity of over 4 million square meters. A wide range of nickel foam specifications is available with excellent mechanical properties, high conductivity and consistent density control. This paper discusses the importance of the raw materials quality (such as the polyurethane substrate and nickel feed material) in the metal foam manufacturing process for achieving a superior quality final product. For high-end battery uses such as HEV NiMH batteries, nickel foam should be free of impurities and possess uniform structure and density distribution, good tensile strength and high electrical conductivity. Inco uses high-purity carbonyl nickel for production of nickel foam in both CVD and electroplating processes. Different methods of preparing thin sheets of open-cell polyurethane foam substrate are described. Morphological effects of PU foam struts are also reported based on SEM studies.

Keywords: nickel foam, polyurethane substrate, cell structure, density uniformity, Incofoam[®]

1. Introduction

Today, nickel-based rechargeable batteries (NiCd and NiMH) have penetrated into many facets of our daily life. Rechargeable battery cells can be found in cameras, cordless power tools, emergency lighting and cordless phones, to name a few. Heavy-duty nickel-metal hydride (NiMH) batteries are used in the production of hybrid electric vehicles (HEV). This leading technology has led to outstanding fuel savings and can dramatically reduce automotive exhaust pollution. One can reasonably believe that in the near future, HEV technology will have considerable economic and environmental impact.

To meet the requirement of nickel-based battery and market applications, Inco has developed production facilities in Wales, UK and China for manufacturing of superior quality nickel foams using both chemical vapor deposition (CVD) and electroplating technologies with a combined annual capacity of over 4 million square meters. This makes Inco the leading nickel foam producer in the world.

This paper discusses the importance of the raw material quality in achieving superior quality of the final nickel foam.

2. Incofoam[®] production

Schematic production flowsheets of the Incofoam[®] production processes are shown in Figure 1.

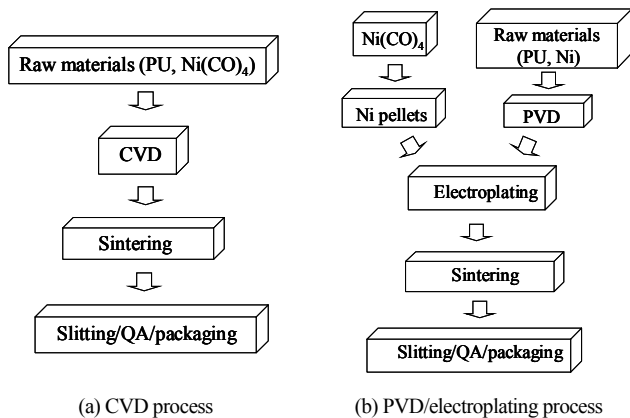


Fig. 1 Nickel foam production processes at INCO Limited.

The CVD process directly uses the nickel refinery gaseous nickel carbonyl ($\text{Ni}(\text{CO})_4$) feed to metallize polyurethane (PU) foam substrates¹. The process offers advantages such as (1) single stage Ni plating on raw polyurethane foam to desired density, (2) automatic process control, (3) uniform Ni deposition, (4) very low impurities due to gaseous carbonyl feed, (5) capability to produce a wide range of foam densities of consistent quality, and (6) no waste water treatment issue. The PVD / electroplating process applies physical vapor deposition (sputtering) to activate the polymer substrate for subsequent nickel electroplating. Highly pure carbonyl nickel-derived pellets are used for the electroplating feed to ensure nickel foam purity. Carbonyl - derived Ni foam products can avoid undesirable impurities such as phosphorus, which can be present in electroless nickel activated foams. Other advantages include uniform transverse and longitudinal density profile allowing high foam product recovery, flexible operation and process capability to make foams with a broad range of specifications. Figure 2 shows typical battery-size pieces of nickel foam and an SEM image of the foam surface.

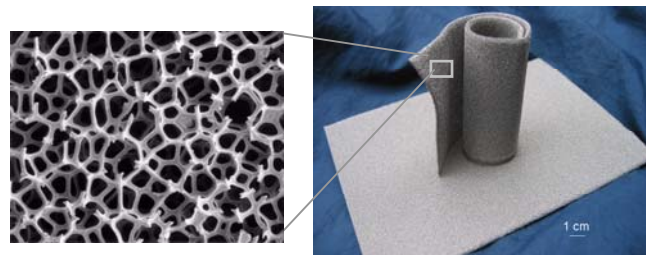


Fig. 2 Battery-size coil and sheet of nickel foam with SEM surface image detail.

A wide range of Ni foam specifications is now available from Inco with consistent density control, good tensile properties and conductivity, resulting in excellent battery electrode performance and potential for many new applications. Figure 3 illustrates the uniformity achievable with the CVD process in producing very light (up to ~98% porous) as well as much higher density nickel foams. Other applications of Incofoam[®] include high temperature filters, catalyst support, heat exchanger and fuel cell electrodes².

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