HIGHER TECHNICAL INSTITUTE

MECHANICAL ENGINEERING COURSE

DIPLOMA PROJECT

MANUFACTURE OF A SUPERHARD COMPOSITE

M/920

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JUNE 2001

MANUFACTURE OF A SUPERHARD COMPOSITE

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Project Report

Submitted to

The Department of Mechanical Engineering

Of the Higher Technical Institute

Nicosia Cyprus

In partial fulfillment of the requirements

For the diploma of

TECHNICIAN ENGINEER

In

MECHANICAL ENGINNEERING

JUNE 2001

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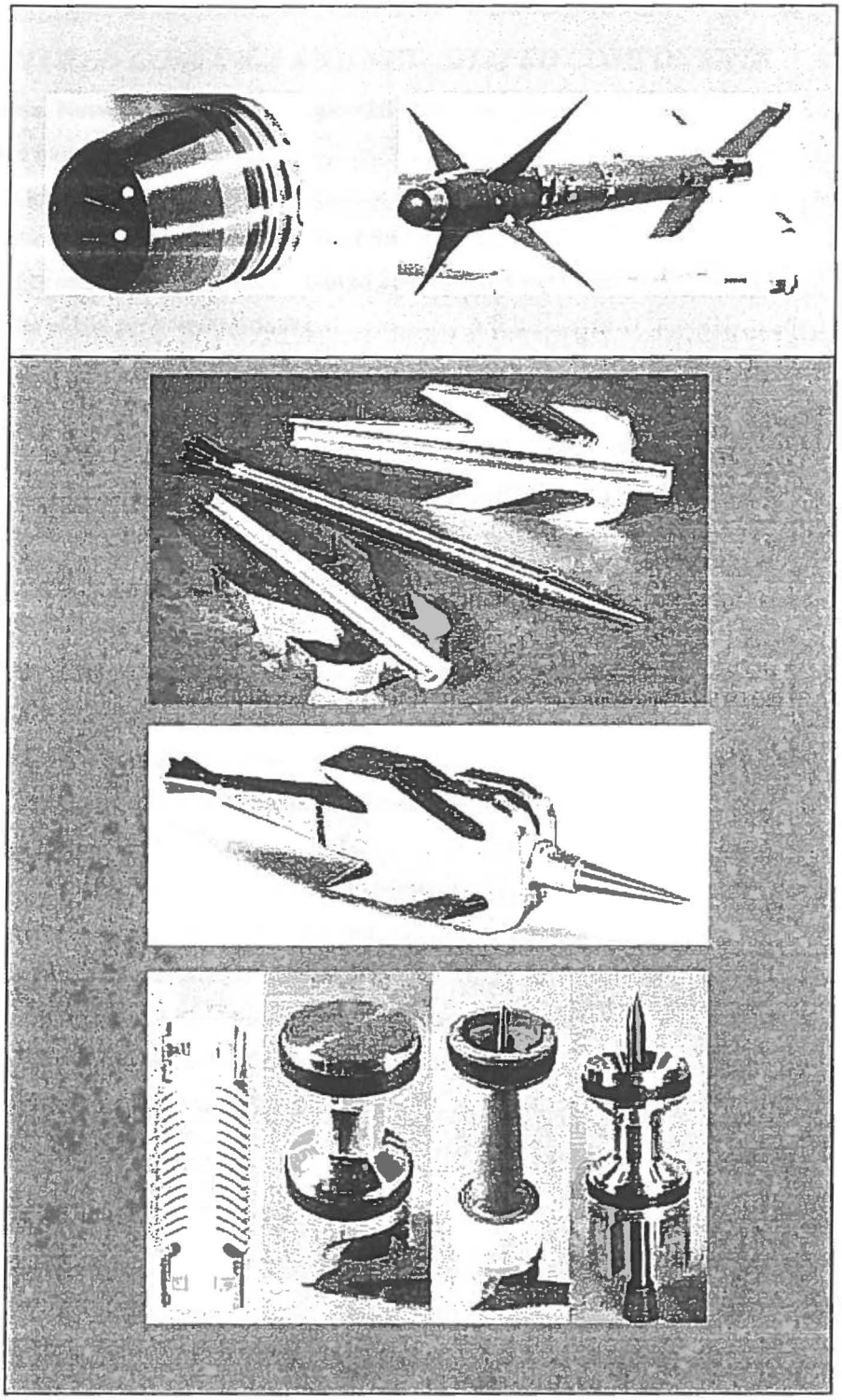

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ABSTRACT

The proposed initiative will establish a multidisciplinary program on the thermochemical processing (powder synthesis and conversion), deposition and/or consolidation of nanophase composites.

The program will focus on three aims: (a) producing metal-metal and metal-ceramic amorphous and nanostructured powders, (b) development of nanostructured coating and consolidation application parameters for superior mechanical, thermal performance and (c) producing custom materials to specification in partnership with our industrial partners.

The initiation of this project falls within the activities of the Nanomaterials Research Center (NRC), a newly established center at HTI which serves as a bridge for technology transfer between HTI and the technology users (industry at large). The primary mission of NRC is to develop new methods for the economical production of nanostructured metals, ceramics, and their composites.

Under this center, two operating divisions have been established, each with its own application goal(s) and commercialization strategy: (1) nanopowder synthesis, which is commercializing high rate production of non-agglomerated nanoparticles and (2) large area deposition of coatings and consolidation of net-shaped parts. Both of the divisions focus on the commercialization of advanced materials processes for enhanced mechanical and thermal properties.

Current programs are focused on methods for the production of nanostructured powders, nanophase coatings (wear resistant surfaces, thermal barriers, selective surfaces for solar thermal and photovoltaic fabrications, semi-permeable membranes) and nanophase composites (gas turbine engines, bulletproof vests and porous membranes).

INTRODUCTION

Objective

The primary objective of this project is to fabricate components in the form of nano (structured) coatings or net-shaped parts from amorphous powders to enhance mechanical and thermal properties.

Advances in high performance materials for structural and thermal applications and the associated deposition and consolidation methodologies will increasingly depend on our ability to control the size, distribution and morphology of their constituent phases at the sub-micrometer or nanometer level. Since capabilities for synthesising, such nanostructured materials in bulk are becoming available, it is now possible to produce quantities of materials needed for prototype development and testing.

Nanostructured materials are a new class of synthetic materials with ultrafine microstructures, somewhat arbitrarily defined as structures smaller than 100 nm. These materials may be composed of metals, ceramics, polymers, and their composites. The materials can be in the form of powders, thin films, porous media, or dense structures.

The primary aim of the proposed project is to exemplify the scientific and technical foundation for the bulk synthesis and deposition of amorphous and nanophase powders. A key feature of this approach will be to couple research on materials synthesis, processing characterization and end-product performance evaluation at all collaborating academic institutions, with work on process scale-up, coating and net-shape prototype development and testing at our industrial affiliates. Such concurrent development should expedite the implementation of nanophase composite technology.

Description

The main steps of the work are:

1) Selection of materials/compounds to be deposited as nanostructured coatings or consolidated net-shaped parts, preparation and mixing of an appropriate starting solution, spray drying of the starting solution to form a chemically homogeneous precursor powder; thermochemical conversion of precursor powders;
2) Determination of size, structure and composition of powder, powder stability, physical/mechanical properties of powder;
3) Analysis of current powder deposition and consolidation methods, influence of the deposition and consolidation method on the final characteristics of the coatings, selection of the most suitable method and definition of all critical parameters of the process;
4) Production of prototypes, either in the form of nanocoatings or net-shaped parts;
5) Determination of mechanical properties and thermal properties, long-term behavior, testing and evaluation of final product.

Milestones Expected

The ultimate goal will be the synthesis of clean amorphous nanocrystalline powders and the manufacture of nanophase coatings and net-shaped parts. The components fabricated out of these amorphous elements/alloys are anticipated to exhibit extraordinary combination of hardness, toughness, abrasion resistance and adherence properties at reduced cost.