Nanyang Technological University
School of Materials Science & Engineering

Final Year Project Proposal 1

Project Title:
3D Assembly of Nano/Micro Zirconia Particles for Enhanced Energy Damping Capacity

Name of Supervisor:
A/P Gan Chee Lip

Academic year/semester:
AY2015/16

Name of Mentor:
Dr Du Zehui (duzehui@ntu.edu.sg)

Project Objectives:
- To develop the best possible method to assemble micro/nano-scale zirconia particles in three dimension (3D)
- To lay out the relationships between the processing parameters, the architecture of the particles assembled and the energy damping capacity

Project Description:
Shape memory zirconia ceramics (SMC) has many potential applications in energy storage and energy damping because of its unique superelasticity properties, i.e. the ability to change its shape upon loading and fully recover after unloading. In this work, the zirconia ceramic particles with excellent superelastic properties will be synthesized and assembled into a 3D architecture. Iterative processing and compressive tests of the assembled particles will be carried out. Optimization of the processing protocols towards the ceramic bodies with enhanced energy damping capacity will be achieved in the end.

Key words: Zirconia, nano/micro-scale particles, 3D architecture, energy damping capacity

Major Tasks:
1. To conduct literature review and analyze the existing state-of-art technologies.
2. To master certain sample preparation skills such as sol-gel processing or spray drying method.
3. To master certain sample characterization skills such as XRD, FESEM, and *in-situ* nanoindentation.
4. To learn how to analyze obtained data and draw meaningful conclusions.
5. To learn how to write a good FYP report
6. To present results at monthly group meetings.
7. To give suggestions for future work.

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Final Year Project Proposal 2

Project Title:
Synthesis of High Strength Zirconia Fibers by Electrospinning Method

Name of Supervisor:
A/P Gan Chee Lip

Academic year/semester:
AY2015/16

Name of Mentor:
Dr Du Zehui (duzehui@ntu.edu.sg)

Project Objectives:
- To develop a feasible method to synthesize zirconia fibers with high mechanical strength
- To lay out the relationships between the processing parameters and microstructure of the fibers
- To evaluate the tensile strength of the as-synthesized zirconia fibers

Project Description:
Zirconia (ZrO_2), as a very important advanced ceramic, has been regarded as a potential shape memory ceramics for actuation application which is, however limited by its low recoverable strain (~1-2%) and strong tendency to crack. In this work, we are exploring to mitigate such problems by developing ZrO_2 ceramics with a nano/micro fiber shape and modifying the composition of the fibers to enhance its mechanical strength. The zirconia fibers will be developed by electrospinning method. The effect of doping and microstructure on the mechanical strength of the fibers will be studied. Iterative processing and tensile tests of the fibers will be carried out. Optimization of the processing protocols towards the ceramic fibers with enhanced mechanical strength (mainly tensile) will be achieved in the end.

Key words: Zirconia, fibers, tensile strength, microstructure, doping

Major Tasks:
1. To conduct literature review and analyze the existing state-of-art technologies.
2. To master certain sample preparation skills, which is electrospinning.
3. To master certain sample characterization skills such as XRD, FESEM, FIB and *in-situ* nanoindentation.
4. To learn how to analyze the obtained data and draw meaningful conclusions.
5. To learn how to write a good FYP report
6. To present results at monthly group meetings.
7. To give suggestions for future work.

Nanyang Technological University
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Final Year Project Proposal 3

Project Title:
Mechanical Characterizations of High Temperature Polymer Encapsulation

Name of Supervisor:
A/P Gan Chee Lip

Academic year/semester:
AY2015/16

Name of Mentor:
Eric Phua Jian Rong (JRPhua@ntu.edu.sg)

Project Objectives:
- To perform mechanical characterizations on high temperature polymers.
- To perform numerical simulation to verify with experimental results.

Project Description:
In offshore oil drilling, different types of microelectronics devices and sensors are needed for logging while drilling (LWD) and measurement while drilling (MWD) purposes. However, the high temperature, high pressure and even changes in electrochemistry in the operating environment, pose a challenge to the electronics packages' survivability. In this project, various modes of characterization are required to identify suitable high temperature polymeric gap fill materials in such electronics packages. Student would acquire required both software and experimental skill for performing mechanical analysis on new materials. No prior simulation experience required.

Key words: High temperature polymers, simulation, high pressure, mechanical properties

Major Tasks:
1. To conduct literature review.
2. To synthesize high temperature polymers.
3. To carry out mechanical characterizations using tools such as Instron tester, high pressure tester, etc.
4. To investigate morphology of high temperature polymers using SEM.
5. To carry out simulation using ANSYS to study the mechanical properties of the electronics package.
6. To learn how to write a good FYP report
7. To present results at monthly group meetings.
8. To give suggestions for future work.

Nanyang Technological University
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Final Year Project Proposal 4

Project Title:
Synthesis and Material Characterizations of High Temperature Polymer Encapsulation

Name of Supervisor:
A/P Gan Chee Lip

Academic year/semester:
AY2015/16

Name of Mentor:
Eric Phua Jian Rong (JRPhua@ntu.edu.sg)

Project Objectives:
- To synthesize high temperature polymer for electronic package encapsulation.
- To perform material characterizations on the synthesized polymers.

Project Description:
In offshore oil drilling, different types of microelectronics devices and sensors are needed for logging while drilling (LWD) and measurement while drilling (MWD) purposes. However, the high temperature, high pressure and even changes in electrochemistry in the operating environment, pose a challenge to the electronics packages' survivability. In this project, various characterizations will be carried out to study a new type of high temperature polymer encapsulation.

Key words: High temperature, polymers, material characterizations, high pressure, reliability

Major Tasks:
1. To conduct literature review and analyze the pros/cons of existing study/products.
2. To improve on current synthesis of the high temperature polymers.
3. To carry out material characterizations using tools such as DSC, TGA, DMA, TMA, FTIR, etc.
4. To investigate morphology of high temperature polymers using SEM.
5. To mold developed polymers into electronic packages.
6. To carry out electrical and mechanical reliability tests.
7. To learn how to write a good FYP report
8. To present results at monthly group meetings.
9. To give suggestions for future work.

Nanyang Technological University
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Final Year Project Proposal 5

Project Title:
Compositional Dependence of Sn-Bi Solder on the Intermetallic Compound (IMC) Growth Kinetics with Cu

Name of Supervisor:
A/P Gan Chee Lip

Academic year/semester:
AY2015/16

Name of Mentor:
Dr Wardhana A. Sasangka (wardhana@smart.mit.edu)

Project Objectives:

- To understand the underlying mechanism on how Sn-Bi composition affects the IMC growth rate with Cu

Project Description:
Incorporating different elements into Sn solder has become an efficient way to control the growth rate of IMCs that form with Cu film. However, which composition allows the fastest/slowest IMC growth is not yet fully understood. From previous experiments on Sn-Bi system, using color change coupled with combinatorial deposition, it has been observed that the fastest IMC growth rate occurs at $Sn_{57}Bi_{43}$ and $Sn_{70}Bi_{30}$. While the former can be explained using eutectic point argument, the latter is still unclear. In this project, effects of Sn-Bi compositions on the IMC growth kinetics will be studied. Different composition of Sn-Bi solder will be prepared by powder mixture. The solder paste will then be smeared on to polished-Cu bars, followed by annealing at different temperatures and time. Sample preparation for cross-sectional analysis will be carried out through grinding and polishing. Finally, scanning electron microscope (SEM) and energy dispersive spectroscopy (EDS) will be used to study the microstructure, composition and thickness of IMC.

Key words: solder, Sn-Bi, IMC, diffusion kinetics

Major Tasks:

1. To conduct literature review on the IMC growth kinetics in Cu/Sn-Bi system.
2. To master sample preparation technique such as: powder mixture to create solder paste, grinding and polishing for cross-sectional analysis and SEM.
3. To learn/understand and apply the concept of diffusion kinetics to the IMC growth mechanism
4. To learn how to write a good FYP report.
5. To present results at monthly group meetings.
6. To give suggestions for future work.

Nanyang Technological University
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Final Year Project Proposal 6

Project Title:
Effects of Sputtering Conditions on the Growth of Indium Nanowires on Cr Film

Name of Supervisor:
A/P Gan Chee Lip

Academic year/semester:
AY2015/16

Name of Mentor:
Dr Wardhana A. Sasangka (wardhana@smart.mit.edu)

Project Objectives:
- To understand the mechanism of Indium nanowires formation as a function of sputtering conditions

Project Description:
In previous experiments, we have observed formation of Indium nanowires after sputter deposition followed by post-annealing in vacuum. The growth locations of these nanowires can be controlled by introducing trenches on the substrate. The lengths of the nanowires can also controlled by varying the size of the circular trenches. Unfortunately, questions on how these nanowires formed have not yet been clearly answered. In this project, sputtering parameters such as deposition pressure, temperature and Cr thickness will be systematically studied by monitoring its effects on the nanowires formation. SEM will be used to check the dimension and location of the nanowires. Surface profiler is needed to measure the thickness of Cr films. Lastly, transmission electron microscope (TEM) may be used to study the microstructure of the nanowire/Cr interface. Understanding the growth mechanism of the nanowires is critical to control the fabrication of these nanowires at large scale. Eventually, this may open up to various applications such as self assembly micro-bumping, nano-interconnects and transparent electrode.

Key words: Indium, nanowires, coarsening, chromium, sputtering

Major Tasks:
1. To conduct literature review on the fabrication of indium nanowires by sputtering.
2. To master the use of sputtering, SEM, and surface profiler.
3. To learn/understand fundamental kinetics of coarsening on the surface.
4. To propose a growth mechanism of the indium nanowires based on experimental evidence.
5. To learn how to write a good FYP report.
6. To present results at monthly group meetings.
7. To give suggestions for future work.

Nanyang Technological University
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Final Year Project Proposal 7

Project Title:
Effects of Cu Nanowires on the Morphology and Mechanical properties of Lead-free Solder Bonding

Name of Supervisor:
A/P Gan Chee Lip

Academic year/semester:
AY2015/16

Name of Mentor:
Dr Lee Byung Hoon (BH.Lee@ntu.edu.sg)

Project Objectives:
- To produce Cu nanowires and employ them on lead-free soldering.
- To carry out electrochemical synthesis and microelectronics bonding using solder materials and mechanical test processes.

Project Description:
Lead-free soldering has been widely used for microelectronics bonding, MEMs hermetic sealing and metallization interconnecting, etc. As the process size decreases, high reliability solder materials, which has low resistivity and high strength are required. Moreover, these properties are still required even at high temperature, because process temperatures of devises are also getting higher. To improve the mechanical properties and microelectronics reliability, Cu nanowires will be implemented on lead-free solder materials in this project. These nanowires will be reacted and transformed to intermetallic compound (IMC), and contribute to enhance the reliability of bonding.

Key words: electrochemical synthesis, lead-free solder, reliability, microelectronics, bonding.

Major Tasks:
1. To conduct literature review on lead-free solders and Cu nanowires.
2. To produce Cu nano-wires by electrochemical process and mix them with lead-free solder paste.
3. To carry out bonding using the solder mixture.
4. To optimize solder paste and bonding parameters such as length of Cu nanowires, mixing ratio, bonding temperature, bonding time, etc.
5. To characterize the microstructures of bonding layer by Scanning Electron Microscope (SEM) and chemical analysis by Energy Dispersive Spectroscopy (EDS).
6. To learn how to write a good FYP report.
7. To present results at monthly group meetings.
8. To give suggestions for future work.

Nanyang Technological University
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Final Year Project Proposal 8

Project Title:
Characterization of Copper Nanoparticle Ink on Flexible Polymer Substrate

Name of Supervisor:
A/P Gan Chee Lip

Academic year/semester:
AY2015/16

Name of Mentor:
Kim Jaewon (JWKim@ntu.edu.sg)

Project Objectives:
- To investigate the sintering behaviour of copper conductive nanoparticles on polymer-based flexible substrate
- To characterize the microstructure and thermal behaviour of the sintered copper nanoparticles

Project Description:
Polymer-based flexible electronics have attracted a lot of attention recently in several applications such as wearable electronics and organic solar cells. The printing technology has been studied for the fabrication of polymer-based flexible electronics due to reduced cost, scalability, low temperature processing, and absence of the additional etching and deposition processes required in conventional subtractive approach. Nano-silver particles ink is currently the predominant type of ink used for printed electronics. As copper is cheaper than gold or silver, nano-copper ink is receiving more attention recently. In this project, we investigate the feasibility of sintering copper nanoparticle ink on polymer-based flexible substrate. The microstructure, thermal properties of Cu nanoparticle ink, and the thermal behaviour of the sintered copper nanoparticle will be investigated.

Key words: Copper nanoparticles, flexible electrode, sintering, printable ink

Major Tasks:
1. To conduct literature review on printed electronics.
2. To process copper nanoparticles ink on polyimide substrates using different methods.
3. To optimize the thermal sintering process.
4. To characterize the Cu nanoparticles ink using TGA and DSC.
5. To characterize the microstructure of the sintered Cu nanoparticles using FESEM and measure its electrical conductivity during sintering by 4-point probe method.
6. To learn how to write a good FYP report.
7. To present results at monthly group meetings.
8. To give suggestions for future work.