UNDERFILL MATERIALS

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ACKNOWLEDGEMENTS

DR. C.P. WONG
(HEAD OF DEPT.)

DR. XIAO FEI
(MY MENTOR)
SOME DIFFERENT BRANCHES THAT MATERIALS SCIENCE AND ENGINEERING AFFECT:

<table>
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<tr>
<th>Branch</th>
<th>Description</th>
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<tr>
<td>MICROELECTRONICS</td>
<td>THIS DIVISION WORKS ON MAKING MICROELECTRONIC UNITS SMALLER, FASTER, AND LESS EXPENSIVE.</td>
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<tr>
<td>TELECOMMUNICATIONS</td>
<td>THIS DIVISION WORKS ON MAKING CELL PHONES MORE AFFORDABLE.</td>
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<td>HEALTH CARE</td>
<td>THIS DIVISION WORKS ON THINGS SUCH AS DEVELOPING ARTIFICIAL SKIN FOR BURN VICTIMS, CHROMIUM ALLOY HIP IMPLANTS, AND ULTRASOUND.</td>
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<tr>
<td>ENERGY PRODUCTION</td>
<td>THIS DIVISION WORKS WITH SOLAR CELLS THAT CONVERT SUNLIGHT TO ELECTRICITY AND MAKING IT MORE COST EFFECTIVE.</td>
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<td>SPORTS</td>
<td>THIS DIVISION MAY DEVELOP STIFFER GOLF CLUBS TO INCREASE DISTANCE, CREATE LOW FRICTION BEARINGS FOR ROLLER BLADES, CREATE LIGHTER BIKES, AND MAKE PARACHUTES MORE RELIABLE AND CONTROLLABLE.</td>
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Dr. Tarasankar Pal from India was working on different things with nanoparticles. He made a few presentations on his work with silver in India. There were other teachers working with him from the GIFT Program.

Yang Yang Sun was working on studying the application of nanocomposite materials in the electronics packaging, including the influence to the curing kinetics, thermal mechanical properties, dielectrics properties and rheology by nano-sized filler.
PROJECT SUMMARY:

- DR. XIAO FEI, THE MENTOR THAT I WAS ASSIGNED TO, WAS WORKING ON FINDING AN UNDERFILL MATERIAL THAT HAS A LOW EXPANSION RATE WHEN EXPOSED TO HIGH TEMPERATURES.

- MATERIALS SCIENCE AND ENGINEERING DEALS WITH A LOT OF CHEMISTRY. A LOT OF IT IS CREATING NEW FORMULATIONS AND TESTING THE FINAL PRODUCTS FOR ITS COEFFICIENT OF THERMAL EXPANSION (CTE).
We used different Poss derivatives to try and come up with an underfill material that would have a low CTE (coefficient of thermal expansion).

\((Q_8H_8)\)
Research methods

- Synthesize POSS derivatives
- Prepare formulation from POSS derivatives and other components
- DSC (differential scanning calorimetry) analysis of the formulation to find the proper curing temperature
- Degas and cure the sample
- TMA measurement to get CTE
- Other thermal and mechanical measurement
WHAT I DID:

- THE FIRST TWO WEEKS INVOLVED A LOT OF READING IN BOOKS.
- I ALSO PERFORMED A GOOD DEAL OF LITERARY SEARCHES ON THE GA TECH ONLINE LIBRARY.
- I MIXED A FEW FORMULATIONS THAT WERE CREATED BY XIAO FEI.
- WE HAD A FIRE DRILL AND A HYDRAZONE CHEMICAL SPILL IN WHICH THE BUILDING WAS EVACUATED!!! 😊
THE FIRST FORMULATION:

- THIS SAMPLE WAS COMPOSED OF:
  - 1.29g $Q_8H_4E_4$
  - 0.5129g MHHPA
  - 10.6mg catalyst

- ONCE I LEFT FOR THE DAY, THE SAMPLE WAS PLACED IN THE VACUUM AND THE OVEN AND CRACKED.

- SO...WE HAD TO START OVER!!!
THE NEXT ONE WE TRIED…

- **THIS ONE WAS MADE OF:**
  - 0.2g EPOXY 828
  - 0.504g $\text{Q}_8\text{H}_5\text{P}_3$ (solid)
  - 3.5mg CATALYST
  - WE ADDED ACETONE TO THE MIXTURE TO DISSOLVE IT AND THEN TRIED TO VACUUM IT OUT.

- **THE RESULT:**
  - BACK TO THE DRAWING BOARD!
SAME FORMULATION - SMALLER SAMPLE

- We mixed the same components together and placed them in 4 small aluminum foil towers thinking this would give us a smaller area to work with as opposed to the larger foil pans.

- We placed them in the vacuum at 60 degrees for 2 hours and then into the oven.

- This didn’t work because the sample crawled up the foil walls and got “lost” in the creases and folds! We threw these away!

- Had to start over.....again!!!!!
HERE WE GO AGAIN!!!

- **THIS TIME WE MIXED:**
  - $Q_8H_5E_3$ .4064g
  - MHHPA .1052g (methyl hexahydrophthalic anhydride)
  - CATALYST 2.8mg
  - INTO THE ALUMINUM DISH THEN THE VACUUM AT 80 DEGREES FOR ONE HOUR AND 100 DEGREES FOR ANOTHER HOUR.
  - THEN THE OVEN...100 DEGREES FOR 4 HOURS AND ANOTHER HOUR AT 160 DEGREES.

- **RESULTS....**
  - THE SAMPLE HAD GAS BUBBLES ON THE EDGES, BUT THE MIDDLE HAD AN AREA THAT WAS ABLE TO BE CUT AND TESTED IN THE TCA MACHINE TO TEST ITS CTE. THIS TEST TOOK ABOUT ONE HOUR. THE CTE WAS ABOUT 160 ppm/C.
  - AN IDEAL/GOOD CTE WOULD BE AROUND 20 ppm/C.
Some other reactions...

- 7/12/05-7/13/05

1. Higher temperature for a shorter time in the vacuum-sample began to cure in the vacuum and then rxn became to quick.

2. Sample was fine in vacuum and crept up the walls in the oven.

- NO GOOD!
7/18/2005
New Sample

- $Q_8H_5P_3$ .2525g(solid)
- Epon 828 .1079g
- $C_{11}Z$-CNS 3.5 mg
- Acetone (just enough to dissolve the sample)
- Sample was placed in the vacuum at room temperature to remove the solvent (acetone). We ran a DSC test to find out the curing temperature of the sample (132 degrees). Sample was then placed in the oven at 70 degrees for one hour and then 130 degrees for 1 hour. Sample filled with bubbles (looked like a foam).
- NO GOOD!!!!
This project is something that will be ongoing. Fei will work for another 1-2 years with the different derivatives of POSS and epoxies to find the right one with a CTE of 20ppm/C.
LESSON PLAN SUMMARY

- STUDENTS WILL SET UP A SIMPLE CIRCUIT USING 2 BULBS, 3 CELLS AND 3 CONNECTING WIRES.
- STUDENTS WILL BE ABLE TO ANSWER, “IS THE CELL THE SOLE SOURCE OF CHARGE IN A CIRCUIT OR DOES CHARGE ORIGINATE IN THE BATTERY?”
LESSON PLAN CONTINUED…

- USING A CAPACITOR TO LIGHT THE BULBS, REMOVING IT AND PLACING IT IN DIFFERENT PLACES IN THE CIRCUIT, TAKING IT OUT COMPLETELY AND INTRODUCING A GENECON, STUDENTS WILL UNDERSTAND THAT CHARGE ALREADY EXISTS IN ALL COMPONENTS OF A CIRCUIT. THE CELL, CAPACITOR, AND THE GENECON ACT AS A SOURCE OF ELECTRIC PRESSURE IN THE CIRCUIT.
THANK YOU!!!