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A Method for Decapsulting Integrated Circuit Chips

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Questions have arisen recently on the Microscopy Listserver about the best way to decapsulate integrated circuit chips. Here is the method that has been developed at the Dallas Device Analysis Operation of Texas Instruments, Inc., and is used by many laboratories here. We find that it works very well.

Note! This procedure uses hot, concentrated acids. Safety precautions are very important. Always make sure you read the MSDSs for the chemicals used and understand the hazards involved.

TOOLS, EQUIPMENT, & SUPPLIES

1. Milling machine and appropriate end mills
2. Fine point permanent marking pen
3. Fume hood properly equipped for exhausting acid fumes and solvent vapors
4. Explosion-proof hot plate
5. Ultrasonic cleaning apparatus
6. An optical microscope capable of 100X to 500X magnification; equipped with a lighting system
7. Chemical-resistant gloves
8. Chemical-resistant laboratory coat
9. Chemical-resistant safety glasses
10. Hand tools (tweezers, scalpels and etc.)
11. Plastic micro-pipette
12. Fuming red nitric acid
13. Yellow nitric acid
14. Methyl alcohol
15. Acetone

1. RECORDING OF PACKAGE MARKINGS

Record all of the device markings that are on the top and bottom sides of the devices prior to starting any of the decap operations.

2. CAVITY MILLING

Determine the exact location of the chip within the package and mark the top of the device package showing the chip perimeter, using the permanent marking pen and a straight edge. A SAM (scanning acoustic microscope) plot or X-ray image may be used to help determine the exact location of the chip and also to determine the thickness of the mold compound covering the chip.

Note: *This should be done on devices having large chips.* Devices with small chips (less than 0.125 inches in their longest dimension) do not require this step. Mill a cavity in the plastic package that is centered over the chip. The size of the milled cavity should typically be 0.050 to 0.100 inches larger than the length and width dimensions of the chip. The depth of the milled cavity depends on the thickness of the mold compound and the location and loop height of the bond wires. During the milling operation use a vacuum line to pick up the loose plastic particles generated. **Caution: do not mill into the bond wires or the chip.** Mill counter bores on devices with chip dimensions greater than 0.400 inches on a side. These counter bores should be made on one or more levels within the bond pad perimeter and at the outermost corners of the cavity. This is necessary to facilitate etching of the

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mold compound at the corners of the chip before the, sides are exposed and subsequent damage to the leadframe. Care must be taken during the milling operation to avoid excessive pressure on the mill resulting in filler-induced damage to the chip P.O. The end mill should not bind, bend, or "smoke" during the milling operations.

3. PACKAGE ETCHING

All etching must be performed in a chemical hood.

Heating of acid or device prior to application of acid must be done using an explosion-proof hot plate. Obtain the appropriate acid for use on the mold compound being removed. Following are the acids that have been identified for the removal of the various mold compounds.

Mold Compound and Acid/Temperature:
Shinitsu: Red fuming nitric acid at 140-150 degrees Celsius
Plascon & Sumitomo: Red fuming or yellow nitric acid 140-150 degrees Celsius

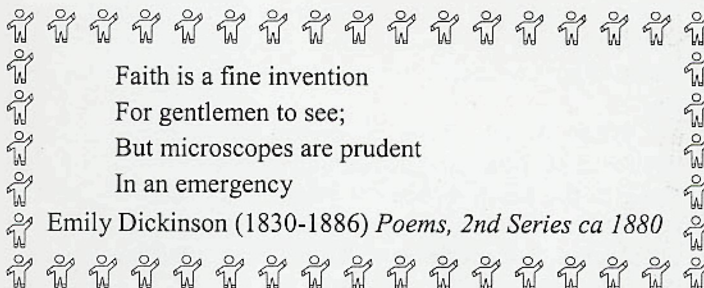
Note: Fuming sulfuric acid reacts with exposed aluminum bond pad metallization and may result in ball bond discontinuity thus hampering further analysis.

When using red fuming nitric acid it may be helpful to start the etching process using a mixture of red and yellow nitric acids in order to slow down the etch process until a "residue crust" is formed over the cavity and then switch to the red nitric acid. Apply the acid in drops using a plastic micro-pipette. The drops should be placed in the center and at the corners of the cavity in approximately a 1:1 ratio. Allow the acid to react with the mold compound and form a crust of dissolved compound. **Caution: Do not allow the crust to dry out completely before adding additional drops of acid.** Remove the dissolved material using cotton swabs or by rinsing with acetone when the dissolved materials threaten to spill over the cavity. **Caution: Rinse the device immediately with acetone if acid spills onto the package pins.** Soak the device in acetone for a minimum of 10 minutes, followed by a spray of methanol to remove loose residue and to clean the residue from the cavity rim. Perform a thorough microscopic inspection to determine whether all necessary areas of the chip are exposed.

If dried mold compound residue persists on the chip surface, use the following in the order shown to attempt removal: Solvent bath (such as methyl alcohol) in ultrasonic cleaner, several drops of room temperature fuming sulfuric acid applied to the chip (with the chip at room temperature) for several seconds then rinse the device in DI water.

Several drops of fuming sulfuric acid applied to the chip with the chip on a 100° Celsius hot plate.

Note: Fuming sulfuric acid will attack aluminum bond pads and is therefore the method of last resort.



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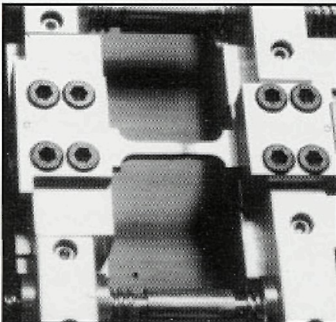

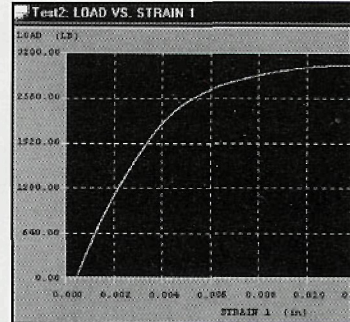

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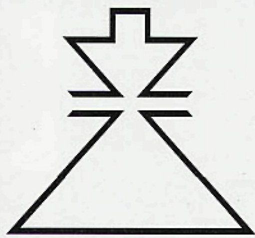

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