Packaging for RIT Microchips, MEMS and Microsystems

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3-11-2013 RIT_Package.ppt
OUTLINE

- Approach
- Commercial Packages
- Custom Packages for MEMS and Microchips
- Wafer Sawing
- Die Attach
- Interconnect
- Covers to Protect Chip and Wire Bonds
- References
APPROACH

Package Itself:
  Purchase Commercial Packages
  Build Custom Packages

Die Attach:
  Epoxy (conductive or non conductive)

Chip to Package Interconnect
  Aluminum Ultrasonic Wire Bond
  Flip Chip with Solder Ball

Protection:
  Epoxy (Black or Clear)
  Plastic Cover
  Metal Can
COMMERCIAL PACKAGES ARE AVAILABLE

TO Packages

Dual-in-line, DIP

$25 to $50 each
COMMERCIAL MEMS PACKAGING

Approach
- Die Attach
- Wire Bond
- Metal Lid
DESIGN GUIDE LINES FOR RIT CUSTOM PACKAGE

Wire bond pad (smallest...larger is okay)
  1 mm center to center
  600 um metal 400 um space

Trace (smallest... larger is okay)
  600 um width
  400 um space

Connector (Pin Strip Header)
  0.1 inch center to center (0.05 inch is possible)

Chip Size (typical)
  10 mm x 10 mm large
  5 mm x 5 mm medium
  2 mm x 2 mm small

Arbitrary dimensions set by Dr. Lynn Fuller

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PIN STRIP HEADERS

3M 929 Series Pin Strip Headers and Sockets
Dual Row and Single Row

0.1 inch center to center (2.54mm x 2.54mm)
0.05 inch center to center (1.27 mm x 1.27mm)
2mm center to center
RIT Custom Chip Packages with 0.1” Pin Header

2mm x 2mm Chip
2-3 Wire Bond Pads

1mmx1mm Grid
Pins 0.1” Centers

2-pin 3-pin 12-pin 20-pin
CUSTOM PRESSURE SENSOR CHIP PACKAGE

Front

5mm x 5mm Chip
Hole for Hose Nipple
5 Wire Bond Pads

RIT

1mmx1mm Grid
Pins 0.1” Centers

Side

Back

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PACKAGED PRESSURE SENSOR

Front

Back
UNIVERSAL PUMP & FLOW SENSOR ASSEMBLY

1” by 3” PCB 0.0125” thick with 0.005” copper

Hose nipples

Plastic cover

Pin strip header

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CROSSECTION

1” by 3” PCB 0.0125” thick with 0.005” copper

Photoresist (film) channel walls
Thickness 50µm to 150µm

Hose nipples
Thermosetting Glue on Plastic cover

Pin strip header

MEMS chip mounted flush with PCB surface, wire bonds from MEMS chip to copper traces
AFTER WIRE BONDS, HEADER AND NIPPLES
These are brass others are plastic and various sizes and shapes
MEMS PACKAGE PCB DESIGN

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**PCB LAYOUTS**

- **3” X 3”**
- Using “Express PCB” free software
- **5” X 5”**
MAKE ARTWORK (TRANSPARENCY)

Select Layer
Scale=1
Black/White

Then print on a transparency
MAKE COPPER BOARD

1. Cut two sided copper board (6”x 9”) into smaller size that can be spin coated with photoresist (3”x 3”). Use shear in machine shop.
2. Clean Board with 400 grit sand paper or very fine steel wool followed by using soap, water and blow dry.
3. Spin coat with photoresist (HPR504) at 1500 rpm, 60 sec., use small 1” chuck.
4. Bake in oven 100°C, 4 min. (gray oven near ion implanter, set 5.5 on the dial to the 150 setting)
5. Place transparency on board and flatten with glass plate
6. Flood expose, (20 sec = ~ 100mj/cm2) on Karl Suss MA150
7. Develop in CD-26 developer (~1 min), inspect
8. Optional test with drop of etch mixture on bare copper area, rinse, dry
9. Hard bake in oven 140°C 15 min
10. Repeat 3 to 9 for other side of two sided board
11. Etch in mixture of Water, H2O2, HCl (3:2:1)
14. Cut board into individual PCB’s using shear in machine shop.
MAKE COPPER PCB BOARD

2-sided copper PCB
1/32” x 6”x9”
473-1011-ND $8.82

Shear
Cut into 3”x 3”

Small Shear
MAKE COPPER PCB BOARD

SCS Spin Coater

Oven
MAKE COPPER PCB BOARD

Etching of PCB
Dr. Lynn Fuller

Flood Expose
(10 sec = ~ 100mj/cm²)
Karl Suss MA150
PCB WITH COMPONENTS ADDED

ADI accelerometers
- ADXL202
- ADXL311
- ADXL78
RIT Packages for Microchips, MEMS & Microsystems

RIT 100X DIFFERENTIAL VOLTAGE AMPLIFIER

1” X 1.5”
CEMA – Center for Electronics Manufacturing and Assembly

Dr. Ramkumar, Ph.D.
Director
Phone: 585-475-6081
Fax: 585-475-7167
E-Mail: gmrmet@rit.edu
Room No: 1518, CIMS

Address:
CEMA
Room 1518
78 Lomb Memorial Dr
Rochester, NY
14623

Jeff Lonneville
jglasp@rit.edu
78-1552

PICK, PLACE AND SOLDER TOOL
SURFACE MOUNT VIDEO

Surface Mount PCB Assembly

Dr. Lynn Fuller
Dr. Ivan Puchades
Nicholas Liotta
Dan Smith
ADXL325 ALIGNMENT IMAGES

Copper Traces with Solder Paste

Image of bottom of ADXL325 Superimposed on Copper Traces
BMA140 ALIGNMENT IMAGES

Copper Traces with Solder Paste

Image of bottom of BMA140 Superimposed on Copper Traces
TEMPERATURE RAMP DURING SOLDERING
XRAY IMAGE OF ADXL325 SOLDER JOINTS

Glenbrook X-Ray Inspection
XRAY IMAGE OF BMA140 SOLDER JOINTS

Shows Possible Problem with Y and Z outputs shorted together
K&S 780 WAFER SAW
Resin-bonded dicing blades are made of epoxy with diamond grit for cutting glass, ceramic, pzt, sapphire, etc. Thermocarbon Inc., 391 Melody Lane, P.O. Box 181220, Casselberry, Florida 32718-1220, Tel (407) 834-7800 supply a variety of metal and resin bonded blades. We have 2.25M-15B-46Ru7-3 hubless blades and hubs to hold them. The blades are $25.50 each in Qty of 10. The 2.25 is 2 1/4 inch diameter, the 15 is 0.015 in thick, the 46 is the diamond grit size in µm. Mike Reeves (800) 523-1946 said that this blade should be good for 1 mm thick glass.

Kulicke and Soffa Industries Inc., Micro-Swiss Division, 2101 Blair Mill Road, Willow Grove, PA 19090 Tel(215)784-6975 make metal bonded and resin bonded dicing blades. Their Resinoid Blades with and without hubs are for cutting glass, ceramics, pzt, sapphire, etc. They also have a wide range of nickel hubless and hub-type blades for silicon and GaAs wafers.
Nitto Denko Corporation (http://www.nitto.com)
Lintec Corp., Tokyo, Japan

UV Light Release ADWILL T-5782, 200 mm x 10 m roll
Extra Sticky, ADWILL G-19, 200 mm x 10 m roll
AFTER SAWING AND REMOVAL OF GOOD CHIPS
Standard 2 Part Epoxy Glue
Hardens in 4 min., full cure in 24 hours.

High Temperature Epoxy Available
FLUID CHANNEL ASSEMBLY FABRICATION

1. Make printed circuit board (See another page)
2. Drill holes for pins and big hole (holes) for microchips
3. Mount chip or chips using blue dicing tape to temporarily hold chip
4. Epoxy chips in place (thermally conductive epoxy?)
5. Remove blue dicing tape
6. Apply sheet photoresist
7. Align and expose photoresist
8. Develop photoresist
9. Hard bake photoresist
10. Cut and laminate plastic channel cover
11. Wire bond MEMS chip to copper traces
12. Drill holes for fluid input and output in cover
13. Epoxy hose nipples
14. Fill with fluid using syringe and test pumping action
15. Gas flow sensors may need heat sink on back of assembly
AFTER MOUNTING CHIP

Drill holes.
Mount chip or chips using blue dicing tape.
Epoxy chips in place.
Remove blue dicing tape.
PHOTOSENSITIVE FILMS

Also ImageOn from RIT Bookstore 12”x10’x0.002” thick for $18
Fluid Alignment keys to match PCB
PCB
Donuts for drill hole alignment
Alignment Keys to match channel
ALIGNMENT OF MASK TO CHIP

Since the ImageOn resist is opaque. It is difficult to align the channel perfectly across the chip as needed. If holes are drilled in two locations (opposite corners) on the PCB the mask can be aligned perfectly prior to applying any ImageOn. Then push pins can be used to make holes in the plastic mask. After the multiple layers of ImageOn are laminated to the board push pins thru the hole will allow the mask to be aligned. Once aligned it is held in place with tape until after exposure.
IMAGEON ULTRA RAPID DRY FILM RESIST

ImageOn Processing –negative working resist, 50µm Thick

Clean and dry substrate
Remove mylar film from the non-shiny side of the resist
Place resist on the substrate (one try, no air bubbles, etc)
Press down from center to edge,
   Laminate or heat on hot 50°C plate with pressure
Remove top mylar film
Repeat to get 100, 150, 200 µm total thickness
Expose: Dose = ~50, 100, 150 or 200 mj/cm²
   Irradiance = 3.5mW/cm² x 15 sec
                  30s for 100µm, 45s for 150µm, etc.
Remove top mylar film
Develop in CD26 (develop 15 sec, spray DI water,
   repeat every 15 sec until clear)
Rinse with water and dry
Hard bake or expose to UV light for 2 min.
150µm DEEP CHANNELS

150µm ImagOn Channels on Glass Substrate
AFTER CHANNEL (NO TOP COVER) DEFINED

PCB with MEMS Chip and Channel Walls
THERMOSETTING GLUE ON PLASTIC COVERS

Plastic used for lamination of nametags, signs, etc. is plastic with a coating of thermosetting glue on one side. This plastic makes a good cover for the fluid channels.

Cut a piece of plastic the right size. Use exacto knife and trace the outline of the channel. Lay it over the channels. Lay a microscope slide or piece of glass to weigh down the plastic. Set it on a hot plate set to 150C. Watch the glue change from frosty to clear. Remove from the hot plate and allow to cool.

Drill a hole in the plastic for inlet and outlet port.
CHIP TO PACKAGE CONNECTION

- Wire Bonds
- Solder Bumps
- Lead Frames
- Connectors
  - Press-fit
  - Zero Insertion Force
WIREBOND PADS FOR PACKAGING

Pads ~0.22mm x 0.22mm
With ~ 0.030mm space
Wire is ~75µm diameter
Bond is ~150 µm diameter
SOLDER BUMP TEST CHIP

1000µm center-to-center
350µm diameter sphere
LEAD FRAMES

2.54mm (0.1”) Center to Center Pad ~ 2mm x 2mm with 1mm space
Epoxy on back holds pins in place
Pressure makes contact, Silver epoxy on front can make more reliable contact.

Lead Frame: LF – 5012-03-260
### CONNECTORS

#### 144 CONTACT(S), FEMALE, RIGHT ANGLE SINGLE PART CARD EDGE CONN, SURFACE MOUNT, SOCKET

This product ships from a Jameco satellite warehouse, usually within 2 to 3 the next business day when received by 5:00PM EST. Please choose expedited processing at checkout if you prefer to have the other products on your order ship immediately. Separate shipping charges would then apply.

<table>
<thead>
<tr>
<th>Jameco P/N</th>
<th>801588PS</th>
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<tbody>
<tr>
<td>Mfg</td>
<td>MOLEX INC.</td>
</tr>
<tr>
<td>Mfg #</td>
<td>54697-1440</td>
</tr>
<tr>
<td>RoHS?</td>
<td>Yes</td>
</tr>
<tr>
<td>In Stock</td>
<td>Y</td>
</tr>
<tr>
<td>Contact Gender</td>
<td>FEMALE</td>
</tr>
<tr>
<td>Filter Feature</td>
<td>NO</td>
</tr>
<tr>
<td>Mixed Contacts</td>
<td>NO</td>
</tr>
<tr>
<td>Mounting Style</td>
<td>RIGHT ANGLE</td>
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<tr>
<td>Mounting Type</td>
<td>BOARD</td>
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<tr>
<td>Number of Rows Loaded</td>
<td>2</td>
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<tr>
<td>Single Part Card Edge Connector Type</td>
<td>SINGLE PART CARD EDGE CONN</td>
</tr>
<tr>
<td>Terminal Pitch (mm)</td>
<td>0.8</td>
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**We tempt you to order at this lowest price.**

*View Technology Data Sheet*

Download a Font Pack

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*Rochester Institute of Technology*

*Microelectronic Engineering*
Bond 1, time=1, power=250
Bond 2, time=2, power=320

Orthodyne Electronics Model 20
Ultrasonic Wire Bonder
Orthodyne Electronics
16700 red Hill Ave
Irvine, CA 92606-4802
(949)660-0440

Bonding Wedge 0.003 V GRV Twin 1CR4-B
Capillary 0.004 Violet narrow guide 1CR4-J

6/9/2006

Semiconductor Packaging Materials, Inc.
1 Labriola Court
Armonk, NY 10504
www.sempck.com
(914) 273-5500

1%SiAl wire, 0.003 inches diameter
Fixture to hold TO-8 and TO-39 packages for wire bonding. Ultrasonic Aluminum Wire bonder.
SOLDER BUMPS ON CHIP

- 350 um Solder Bump
- 0.5 um Ni
- 0.1 um Cr
- 1um Al/1%Si

Flip Chip Attach to PCB or Flex Circuit or Tiny Wires
RIT SOLDER BUMP PROCESS

1. Aluminum already on microchip
2. Deposit 1µm of TEOS
3. Photo for etching vias in TEOS (normal positive resist)
4. Etch vias (over etch a little to get undercut for lift-off)
5. Sputter Cr (1000Å), Ni (5000Å) single pump down
6. Sputter Cu (5,000Å) (optional)
7. Lift-Off in acetone using ultrasonic agitation
8. Put down 150µm of the Blue photoresist (negative)
9. Expose and develop openings over the under bump metal
10. Squeege solder paste filling the openings
11. Heat on hot plate to melt solder and form bumps
12. Solvent strip blue resist off and clean solder flux off
PHOTOSENSITIVE FILMS

http://www.rayzist.com/

Blue Negative Resist

<table>
<thead>
<tr>
<th>Thickness</th>
<th>595 sq in</th>
<th>5 Sheets 8.5” x 14”</th>
<th>1190 sq in</th>
<th>10 Sheets 8.5” x 14”</th>
<th>2975 sq in</th>
<th>25 Sheets 8.5” x 14”</th>
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<tr>
<td>3 mil</td>
<td>$0.63</td>
<td>$37.49</td>
<td>$0.058</td>
<td>$69.02</td>
<td>$0.053</td>
<td>$157.68</td>
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<tr>
<td>4 mil</td>
<td>$0.68</td>
<td>$40.46</td>
<td>$0.063</td>
<td>$74.97</td>
<td>$0.058</td>
<td>$172.55</td>
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<tr>
<td>5 mil</td>
<td>$0.073</td>
<td>$43.44</td>
<td>$0.068</td>
<td>$80.92</td>
<td>$0.063</td>
<td>$187.43</td>
</tr>
</tbody>
</table>

Also ImageOn from RIT Bookstore 12”x10’x0.002” thick for $18
ImageOn Processing – negative working resist, 50µm Thick

- Wet Substrate
  - Remove mylar film from the non-shiny side of the resist
  - Place resist on the wet substrate
  - Remove water from center to edge,
    - Laminate or heat on hot plate with pressure
  - Remove top mylar film
  - Repeat to get 100, 150, 200 µm total thickness

- Expose: Dose = \(~50\, \text{mj/cm}^2\),
  - Irradiance = \(3.5\, \text{mW/cm}^2 \times 15\, \text{sec}\)
    - 30s for 100µm, 45s for 150µm, etc.

- Remove top mylar film
- Develop in CD26 (develop 15 sec, spray DI water, repeat every 15 sec until clear)
- Rinse with water and dry
- Hard bake or expose to UV light for 2 min.
**PROCESS DETAILS**

- **Completed CMOS wafer with Al Metal**
- **Deposit 1µm TEOS or LTO**
- **Normal Positive Photoresist Via**
- **Over etch to create undercut**
- **Deposit Cr and Ni**
- **Lift-Off in Acetone and ultrasonic**
PROCESS DETAILS

1. Apply and Image 150µm Thick Neg. Photoresist
2. Squeege Fill with Solder Paste
3. Hot Plate Heat to form Bumps
4. Solvent Strip 150µm Photoresist
MASK LAYOUT FOR TRIAL SOLDER BUMPS
PICTURES DURING PROCESS

After Imaging 150µm Resist Over Under Bump (Cr/Ni) Metal

After Stripping Resist in Solvent Strip

1mm space, 350 µm Diameter Bump

After Spreading Solder Paste into holes and heating to form Solder Balls
SOLDER PASTE
TINY WIRE SOLDERED TO ONE BUMP
INTERCONNECT TO PCB
PROTECTION

Epoxy
Metal Covers
Plastic Covers
**EPOXY FOR CHIP PROTECTION**

Conductive epoxy is printed, chips are placed on board (tacky epoxy holds them in place), oven cure of epoxy. Conductive epoxy is used under the chip where electrical or thermal conductivity is needed.

Non conductive epoxy used to cover the chip. Epoxy forms a dam and a different type of epoxy fills and protects.
# EPOXY MATERIALS

## Master Bond Inc

154 Hobart St.
Hackensack, NJ 07601

(201) 343-8983

Offers over 100 different epoxy products, adhesives, sealants and coating.

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Mix Ratio</th>
<th>Viscosity, RT, cps</th>
<th>Set-up time, RT</th>
<th>Cure Schedule</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP21TDCS</td>
<td>100/100</td>
<td>Thixotropic</td>
<td>30min</td>
<td><em>48hrs @ RT+2hrs @ 200F</em></td>
<td>Silver Epoxy 20 grams min. sample $230 Polysulfide modified, Fuel and oil resistant sealant</td>
</tr>
<tr>
<td>EP21TPND</td>
<td>100/100</td>
<td>Thixotropic</td>
<td>30min</td>
<td><em>24hrs @ RT+3hrs @ 200F</em></td>
<td>Exceptionally low coefficient of expansion, low shrinkage</td>
</tr>
<tr>
<td>EP30LTE</td>
<td>100/10</td>
<td>17,000</td>
<td>30min</td>
<td><em>24hrs @ RT+2hrs @ 200F</em></td>
<td>Polysulfide modified, Fuel and oil resistant sealant</td>
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<tr>
<td>EP30</td>
<td>100/10</td>
<td>2000</td>
<td>25min</td>
<td><em>24hrs @ RT+2hrs @ 200F</em></td>
<td>Polysulfide modified, Fuel and oil resistant sealant</td>
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<tr>
<td>EP77M-F</td>
<td>100/100</td>
<td>Paste</td>
<td>8min</td>
<td><em>1hr @ 150F+8hr @ 300F</em></td>
<td>Electrically conductive silver filled epoxy</td>
</tr>
<tr>
<td>EP121AO</td>
<td>100/80</td>
<td>50,000</td>
<td>15hrs</td>
<td><em>3hrs @ 200F+9hrs @ 200F</em></td>
<td>Thermally conductive potting and encapsulation</td>
</tr>
<tr>
<td>SuperGel#7</td>
<td>100/100</td>
<td>500</td>
<td>3hrs</td>
<td><em>60hrs @ RT+3hrs @ 200C</em></td>
<td>Soft resilient, transparent epoxy gel</td>
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<tr>
<td>SteelMaster 43HT</td>
<td>100/20</td>
<td>Thixotropic</td>
<td>25min</td>
<td><em>24hr @ RT+2hr @ 200C</em></td>
<td>Machinable, stainless steel filled</td>
</tr>
</tbody>
</table>

[Rochester Institute of Technology Microelectronic Engineering](http://www.masterbond.com)
PLASTIC COVERS FROM SQUARE PLASTIC TUBE

Cut Square Tube

Print covers on transparency sheets, cut and glue

http://www.hobbylinc.com
PURCHASED METAL COVERS

TO-8
RIT PACKAGED PRESSURE SENSOR
ADI ACCELEROMETERS
FREESCALE’S PRESSURE SENSOR PACKAGES
Siemens microrelay in SO-8 package
USING PACKAGED RIT PRESSURE SENSOR

Apply pressure, measure and compare with other pressure gages. Collect data.
PACKAGED AIR FLOW SENSOR
REFERENCES

5. Indium Corporation of America, 1676 Lincoln Ave., Utica, NY 13502, Tel (315) 768-6400
10. Universal Laser Inc. www.ulsinc.com
REFERENCES (Cont)


13. Hobby shops for glue, etc. such as kitkraft.inc [www.kitkraft.biz](http://www.kitkraft.biz) for ½” square plastic tubing, 15” long $2.20 each SKU ST-16