RJR Polymers Overview

The Total Electronic Package Solution
Company Vitals

- Privately held company headquartered in Oakland, California
  - Founded in 1987
  - 50,000 + square foot facilities
  - 100 employees
  - Satellite Office in Tempe, Arizona
  - Worldwide Representatives

- RJR provides:
  - Air Cavity Packages
  - Package Assembly Equipment
  - Pre-Applied Epoxy Coated Components

- Strong technology position with key patents granted for IP protection

- Keys to success
  - Technology leadership
  - Focused markets and customers
  - Agility and flexibility
  - Partnering

- ISO9001 certified
Vision & Mission

VISION
To be the best provider of advanced electronic packaging solutions to the semiconductor industry.

MISSION:
RJR Polymers provides electronic packaging solutions through the development and manufacture of air cavity packages, pre-applied epoxies, and sealing systems. Our foundation and strength are our people, engineered materials and sealing processes. The mission is to deliver high value, high quality products, and to continuously improve all aspects of our business to exceed our customers needs in order to achieve profitable growth.
People

Management:
- Raymond Bregante – Executive Chairman & Co-Founder
  - Co-Inventor of the key 3 piece package IP
  - Financial backer for RJR Polymers since inception
- Richard J. Ross – Epoxies CTO & Co-Founder
  - Inventor of the key technologies used in our Epoxy formulations and co-inventor of the key 3 piece package IP
  - Materials Developer for our core technologies
- Wil Salhuana – President & CEO
  - Previously was VP & GM at Motorola until he left to start HVVi Semiconductors, where he was President & CEO.

Advisory Board:
- Peter Zdebel, PhD
  - Recently retired Sr V.P. & CTO of On Semi
  - Over 35 years of semiconductor with over 40 patents granted
- Mike Sanna
  - Semiconductor industry consultant
  - Retired VP & GM at Triquint
- Keith Warble
  - RF design consultant
  - Retired VP at Motorola and a lead technologist on cellular and satellite systems
RJR Technologies

- Injection Molded Air Cavity Packages
- Design & Automation
- Sealing Equipment
- Pre-Applied Adhesives

RJR Polymers, Inc.
Product Offering

- LCP (Liquid Crystal Polymer) Packages
  - RF Power
  - QFN
- Package Assembly Equipment
  - Semi automatic IsoThermal Sealing (ITS) Equipment-patented process
- Pre-Applied Epoxy Coated Components
  - Covers for Air Cavity Packages
  - Glass Windows for Vision & Sensor Devices
  - Components for medical devices and other components
RJR LCP Air Cavity Packages

- Improved RF Performance
  - Reduced thermal resistance - thermally enhanced metal based air cavity packages
    - Enables use of Cu bases for RF Power packages
    - Direct connection to Cu die pad for RQFN package
  - Reduced parasitic effects
    - LCP sidewall reduce capacitance of RF Power package
    - Solid metal die pad reduces source inductance in RQFN package

- Reduced Design Cycle Time
  - Flexibility with etched lead frames
  - Reuse on package size production tooling

- Cost Reduction Roadmap
  - In-strip array process for automation in assembly
RF Power Market Space

- Replace existing ceramic Air Cavity packages with an equivalent plastic molded solution
- Major competitors – Kyocera, Sumitomo and Materion
- RJR’s Disruptive Technology – LCP Packages - Offers better performance, maximum flexibility and integration at lower cost than ceramic
- Offer high degree of design flexibility
- Major advantage in using higher thermal management materials.
- Lower cost on both piece parts and assembly process
Flexibility in RF Power Packages

- **Lid**
- **Sidewall**
- **Base**

### Materials

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<tr>
<th>Part</th>
<th>Material</th>
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<tbody>
<tr>
<td>Sidewall Body</td>
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<td>Lid Glue</td>
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**Finished Packages**
Platform Approach

Standardize
- Leadframe size/features
- One mold per family
- Mfg flow/process
- Reuse tooling

Performance
- Leak free
- MSL3
- High Yield

Innovation
- In Strip
- NiPdAu

Flexibility
- Design for families
- Shorter cycle times
- Any base material

Low Cost
# Package Product Portfolio

## RF Power

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<tr>
<th>Part Type</th>
<th>Part Number (S/I)</th>
<th>Configuration</th>
<th>Length (mil)</th>
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<td>SW0800-6E/F</td>
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<td>1620</td>
<td>400</td>
<td>64</td>
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## RF Power Product Roadmap

### GEN 1 (LD) Now
- Passes 0hr Gross leak and other reliability tests

### GEN 2 (SW) Now
- Passes MSL3 and other standard reliability tests

### GEN 3 (Instrip SW) Dec 2012
- Lower cost
- In-strip assembly

### GEN 4 (Instrip Headers) 3Q13
- Lower cost
- Header configuration
- AuSn eutectic die attach

### Goals
- Passes 0hr Gross leak and other reliability tests
- Passes MSL3 and other standard reliability tests
- Lower cost
- In-strip assembly

### Ringframe
- Improved bonding process for more robust product
- New lids
- New leadframes
- Pre-plated leadframe NiPdAu (PPF)
- Base sealed to ringframe
- New LCP material

### Plating
- 100/80/60u gold base
- 30u/10u gold leads
- Post plated NiPdAu
- Preplated NiPdAu

### Assembly Process
- Eutectic die attach
- Bolt-down
- LCP bolt-down lid
- Earless solder reflow
- In-strip assembly

### Base
- CuW
- CPC
- Cu
- CPC
- Cu
High Thermal Conductivity Base Options

- RJR Sidewalls can be attached to many high TC bases
- Including Cu base which provide:
  - Significant thermal improvement
  - Lower cost (Cu base)
  - Not compatible with ceramic
- Preferred base suppliers:
  - Plansee – CPC
  - Interplex - Cu

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<th>Material</th>
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<td>Cu</td>
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<tr>
<td>Al/Cu-diam</td>
<td>500 - 1000</td>
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</table>

Base Properties

Thermal Simulation Results

Rjc Relative to CPC

- CuW (170)
- Cu (210)
- CPC (1:4:1)
- Super CMC (260)
- Super CMC (350)
- Super Cu (390)
- Al (500)
- Al (600)

- 4 mil Si

Material k (W/mC) CTE Cost
CuW 160 - 210 6 - 9 med
CPC 250 8 - 10 med
Super CPC 260 - 370 7 - 10 med/hi
Cu 390 17 low
Al/Cu-diam 500 - 1000 7 - 12 hi
Bolt Down Lid

- **Advantages**
  - Thermal/RF improvement
    - Cu base
    - Improved contact
  - Lower cost
    - Cu base
    - Less Cu and Au
    - Bolt down lid replaces standard lid
Product Robustness

- **Defining parameters**
  - More experiments with more parts
  - Process variability impact
  - Material variability impact
  - “Corner lot” experiments
  - Handling criteria
  - Materials characterization and reliability testing

- **Ensuring excellent, repeatable quality**
  - Documentation of spec’s, procedures, etc based on data
  - Implement fixes and/or screening to meet spec’s

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<th>High Corner</th>
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<td>23%</td>
<td>21%</td>
<td>19%</td>
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<td>8 min</td>
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<td>1 day, 20C</td>
<td>7 days, 24C</td>
<td>14 days, 28C</td>
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<tr>
<td>B-stage time</td>
<td>30 min</td>
<td>33 min</td>
<td>36 min</td>
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<td>3 days, 2C</td>
<td>7 days, 20C</td>
<td>14 days, 35C</td>
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</table>
In-Strip Assembly
RF Power Package
Move to In Strip

Current LD602 Lead Frame

New SW0800-6 Lead Frame

LD602 Product

SW0800-6
In Strip or Singulated
In Strip Assembly

- ITS for in strip assembly
  - 10” x 14”
  - 4 strips per side
  - Automated opening and closing
  - Improved safety features

10 x 14 ITS

In Strip Shipping Trays
## RF Power Gen2

### Reliability Test Results

#### RF Power Packages (LD803)

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<tr>
<th>Stress</th>
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<th>Ref.</th>
<th>Conditions</th>
<th>Duration/Accept</th>
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<th>Lot B</th>
<th>Lot C</th>
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<td>MSL 3</td>
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<td>J-STD-020D</td>
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<td>Temperature Cycling</td>
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<td>-65°C to +150°C</td>
<td>1000 cycles / 0 Fail</td>
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<td>High Temperature Storage Life</td>
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Package Family Manufacturing Tools

For same family size (SW1230, SW0800, etc.) the same tools can be re-used for different leadframe configurations.
RF Power Package Product Development Flow

- **Tool Design**
  - Make Tool
  - Dial-in Tool
  - Rework (Y/N)
  - Acceptance of Tool

- **Leadframe Design**
  - Mfg L/F

- **Materials Development**

- **Lid Design**
  - Make Tool
  - Dial-in Tool
  - Rework
  - Acceptance of Tool

- **Sealing Process & System (ITS)**
  - Make ITS Plates
  - SPC
  - FMEA
  - Thermal & Mechanical Simulation

- **Base Selection**

- **Manufacture Sidewalls (Protos, Pre-Qual, Qual or Production)**

- **Assemble Parts**

- **Reliability Tests for Qualification & Release to Production**

Legend:
- **RJR Task**
- **Revenue Producing**
- **Outsourced**
SOT539/Ni1230 8-Lead Cost-Down Roadmap

**Availability**
- **NOW Gen 1.5**
- **NOW Gen 2.0**
- **2H12 Gen 3.0**

**Product**
- **NiAu Sidewall**
  - 40–100u” Ni, 30u Au
- **Postplated NiPdAu Sidewall**
  - 10–100u” Ni, 5–15u” Pd, 0.5–2u” Au
- **Preplated NiPdAu Sidewall**
  - 20–48u” Ni, 1.2–4.4u” Pd, 0.11–0.48u” Au

**Pricing**
- **NOW Gen 1.5**
  - Ringframe: $4.32
  - Base: $5.00
  - Lid: $0.38
  - Embossing: $0.10
  - **Total:** $9.80
- **NOW Gen 2.0**
  - Ringframe: $3.45
  - Base: $5.00
  - Lid: $0.38
  - Embossing: $0.10
  - **Total:** $8.93
- **2H12 Gen 3.0**
  - Ringframe: $1.89
  - Base: $5.00
  - Lid: $0.38
  - Embossing: $0.10
  - **Total:** $7.37

**Note:**
- Prices are with Au @$1600/TO
- Pricing is for volumes of 1M units/year
SOT502/Ni780 6-Lead Cost-Down Roadmap

**Availability**
- **NOW Gen 1.5**
- **NOW Gen 2.0**
- **2H12 Gen 3.0**

**Product**
- **NiAu Sidewall**
  - 40-100u” Ni, 30u Au
- **Postplated NiPdAu Sidewall**
  - 10-100u” Ni, 5-15u”Pd, 0.5-2u” Au
- **Preplated NiPdAu Sidewall**
  - 20-48u” Ni, 1.2-4.4u” Pd, 0.11-0.48u” Au

**Pricing**
- **NOW Gen 1.5**
  - $2.68
  - Ringframe $2.68
  - Base $2.60
  - Lid $0.31
  - Embossing $0.10
  - Total: $5.69
- **NOW Gen 2.0**
  - $2.14
  - Ringframe $2.14
  - Base $2.60
  - Lid $0.31
  - Embossing $0.10
  - Total: $5.15
- **2H12 Gen 3.0**
  - $1.42
  - Ringframe $1.42
  - Base $2.60
  - Lid $0.31
  - Embossing $0.10
  - Total: $4.43

Note:
- Prices are with Au @$1600/TO
- Pricing is for volumes of 1M units/year
**New Product Cycle Times**

**TODAY**

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**GOAL**

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**Derivative Product**

- Requires new dedam/deflash & singulation Tools

**Task**

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**Derivative Product**

- Reuse all tooling

**Task**

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# RJR’s QFN Product Roadmap

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<td>Goals</td>
<td>+ Improved reliability + Passes GL, MSL3 and TC (-40°C to 125°C)</td>
<td>+ Leadframe assembly + Lower cost</td>
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<tr>
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<td>Assembly Process</td>
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<td>+ Instrip assembly</td>
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<td>Leadframe</td>
<td>+ Copper 194</td>
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## Package Product Portfolio

### RQFN

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RQFN Roadmap

Gen 2.0
MSL3 260°C
- RQFN44-12A
- RQFN55-24A
- RQFN66-32A

2013

G-S-G Customization
- RQFN33-8A/B
- RQFN44-8A/B
- RQFN55-14A/B
- RQFN55-18A/B
- RQFN66-18A/B
- RQFN66-24A/B
- RQFN66-24B
- RQFN66-32A
- RQFN66-32B

2014

Gen 2.5
Arrays
- RQFN44-12B
- RQFN44-12A
- RQFN55-14B
- RQFN55-24A/B
- RQFN55-24B
- RQFN44-12B

2015
RQFN Gen2 Reliability

- New formulation of dielectric material
- New molding process and equipment
- Updated design rules
- 4x4 and 5x5 RQFN’s qualified:

### QFN Microwave Package (RQFN44-12A, RQFN55-24A)*

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<th>Stress</th>
<th>Abbv.</th>
<th>Ref.</th>
<th>Conditions</th>
<th>Duration/Accept</th>
<th>Lot A</th>
<th>Lot B</th>
<th>Lot C</th>
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<tr>
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<td>MSL3</td>
<td>J-STD-020D</td>
<td>IR = 260°C</td>
<td>End Point / 0 Fail</td>
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<td>TC</td>
<td>JESD22-A104</td>
<td>Condition G (-40°C to +125°C)</td>
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* Test results shown are for RQFN55-24-A qual lots. Completed qualification included third RQFN44-12-A lot
RQFN vs Ceramic QFN

**Advantages of RQFN:**
- Direct soldering of die pad to PCB results in:
  - Better grounding for RF applications
  - Better thermal performance
- Opportunity to ship in an array for:
  - Lower cost assembly operations

**Ceramic QFN:**
- Die to PCB path is through vias which degrades:
  - Grounding
  - Thermal performance
- Shipped singulated
RJR’s Pre-Applied Components

- Our Pre-applied B-stage epoxies for Packages can stick to:
  - Plastic
  - Composites
  - Glass
  - Ceramic
  - Metal

Adhesive Options
- Thermo-Set
- Electrically Conductive
- Thermally Conductive

Glass Windows
- For CCD, CMOS and other Vision Devices
RJR’S Optical Glass Covers

- **Standard Products**
  - Borosilicate glass
    - Schott D263, Corning 1737F, Corning D211
    - Supplied in standard thicknesses of 0.54mm and 0.71mm
  - Glass covers are supplied cut to customers specifications, B stage epoxy applied and shipped on tape and rings (plastic or metal) to the customer
  - Typical epoxy dispense pattern:
    - 0.76/1.40mm wide
    - 0.05/0.2mm height
    - 0.25mm typical pullback from edge

- **Standard AR and IR Coatings available**
- **Glass capacity to millions of units per month**
Semiautomatic to fully Automatic designs

Custom Design to meet the customers needs

Simple process because it Controls:
  - Time
  - Pressure
  - Temperature

99% + Yield
Manufacturing Capabilities

RJR continually invests to better serve our customers with leading products with the highest quality, technical support, flexible high volume manufacturing capacity, reduced time to market and lowest costs.

- High Speed Epoxy Lid Coating
- Automated Injection Molding Handling System
- Fully Automated Epoxy Curing Lines
- Mold Tooling
- New Dedam / Deflash And Singulation Tools
- High Speed Automated CNC For Rapid Turns In Tooling
- Low Cost Unified Packaging Platform
Supply Chain

Technology Development

Tooling
- Mold
- Dedam/Deflash
- Singulation

Tool & Package Design

Internal East West - China

Materials & Sealing Processes

Manufacturing Process

- Primer Application
- Molding
- Dedam
- Post Mold Inspection
- Post Plating (Optional)
- Singulation (Optional)
- Dispensing
- Inspection & Packaging

Plating

Leadframe
Building the Right Product

Manufacturing System

Customers → Product Requirements → Customer Expectations:
- High Quality
- High Performance
- Low Cost
- Short Lead Times
- Application notes on sealing process and assembly
- Characterization of customer's assembly process

All disciplines involved concurrently:
- Marketing & Sales
- Technology Development
  - Engineering
  - Purchasing
    - QA
  - Automation
  - Operations
  - Manufacturing

Process 1 → Process 2 → Process N
- Metrics
- Defined Gate

Process Owner 1 → Process Owner 2 → Process Owner N

Customers → Products
# Definition of Samples

<table>
<thead>
<tr>
<th>Definition</th>
<th>Production L/F</th>
<th>Prototype Tooling</th>
<th>Production Tooling</th>
<th>Mfg Process Frozen</th>
<th>Basic Tests PASS</th>
<th>Pre-Qual Tests PASS</th>
<th>Qual PASS</th>
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**Note:**
- Samples are accompanied by a data sheet and paperwork that states the conditions of the materials shipped.
Summary

- RJR is an added value supplier of pre-applied epoxies for various market applications with a solid 25 year track record.

- Based on materials and automation expertise, RJR provides high throughput sealing equipment with over 600 installed WW.

- RJR is a leading supplier of air cavity plastic packages based on LCP.
  - Focused product developments in RF power and QFN

- Leadership RF Power and QFN products offers customers:
  - Best performance for high power and/or high frequency applications
  - Maximum flexibility with thermal bases, leadframe designs and plating
  - Lower Cost for parts, assembly process and tooling

- Growing profitably and generating cash.
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THANK YOU
BACKUP