**IMPROVED OPEN ENDED MICROWAVE OVEN SYSTEM**

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**Project Overview**

An enhanced open ended waveguide cavity oven is presented with improved uniform heating, heating rate and energy efficiency for the microwave curing of bump underfills and encapsulants. The open oven has the potential to provide fast alignment of devices during flip chip assembly, direct chip attach (DCA), surface mount assembly (SMA), wafer-scale level packaging (WLP), MEMS and MOEMS devices with simultaneous curing. The cavity is to be mounted on the arm of a high precision placement machines thereby permitting simultaneous alignment and curing. Combining curing and conventional assembly processes into a single stage also suggests the open-ended geometry can offer productivity gains and lead to more efficient assembly process.

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**Cavity Geometry**

- Cavity resonators are usually formed with short circuit termination at each end, in forms of closed metal boxes. Resonant modes are formed with trapped electromagnetic waves between the short circuit, at one end, and a quasi open circuit formed by the electron beam interface at the other.
- If the waveguide is partially filled with a low loss dielectric material (above), a resonant cavity can be formed in the form of a "cavetron". Radiation losses can be minimised if the air region, the waveguide is cut-off.

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**Optimization of Evanescent Heating Field**

- An additional low loss dielectric material is placed within the air region (above center).
- Adjustment of the length and permittivity of the insert will change the boundary condition experienced by the TM (transverse magnetic) mode wavefront front hitting the bulk dielectric.
- Therefore, tuning the length of the insert, with a given permittivity, allows the optimum boundary condition to be found where the normal electric field within the cut-off section of waveguide, will experience heating if sufficient power is supplied. Therefore, the open-ended cavity becomes an open oven.

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**Design of Open Ended Microwave Oven System**

- To compare the net input power net power flow between the optimised and non-optimised heating, see step 1 and the optimised heating step 2 in Table 1. The net power flow during the heating cycle. The net power flow for each case is shown below.
- The fiber optic sensor is inserted into a ceramic female which is later inserted into the curing material.
- A typical cure profile consists of a ramp-up period, a hold period and a ramp down period.
- Monitoring of the curing of the materials can be achieved by (a) measuring the temperature at about 100 millisecond time intervals in the material, (b) comparing this temperature with a programmed temperature profile and (c) pulsing the microwave source accordingly.
- This control feedback system monitors the heating temperature and has the potential to stabilize temperature ramp up and down rates, multiple hold temperatures and curing time intervals. The Labview program user interface is shown below.

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**Experimental Results**

- The encapsulated experiment in the study is E01080 manufactured by the Company "Waltex".
- Modulated DSC analysis was performed using a Perkin Elmer DSC-7 device to study the curing behaviour of the microstructures.
- The test specimen consists of an adhesive coated on to the cover slips or coverslips are dissipated at intervals of about 600°C. and the overall thickness of the sample varies between approximately 1 mm and 1.5 mm.
- A temperature profile has been specified in the torque and thermal cycles of the paste manufacturers for curing tests. A sample cured specimen is shown below.
- An LSH04C-12 voltage regulator chip has been encapsulated in a QFN package using air with the improved open oven system and successfully tested for functionality (Fig. above).

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**Conclusions**

- An improved open end oven system that can assist in the thermal processing of various MEMS, MOEMS and microelectronic encapsulation processes is presented.
- Implementation of this oven for MEMS and microelectronics device packaging requiring low temperature curing and curing temperature uniformity of the processes. A successful test of the prototype oven with an E01080 encapsulant hot plate has been achieved.
- This paper describes a new microwave curing technique for the curing of SMT components and digital encapsulation materials.