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FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY

1 *Graphite between power semiconductor and insulating substrate for heat spreading and life time improvement*

CTE MANAGEMENT

GRAPHITE MATERIAL FOR POWER MODULES

Conceptional idea

- Life time improvement by matching of thermal expansion coefficient by graphite
- Life time improvement by overall CTE management
- Heatspreader between semiconductor die and insulating substrate or base plate configuration
- Direct bonding of graphite to ceramic insulator by different joining technologies

Conceptional investigation

- Evaluation of cooling, heat spreading by special graphite material
- 3D simulation of thermal behaviour
- 3D simulation of electrical performance especially for the graphite material
- Analytical calculation of three layer spreading resistance

Packaging

- Metallization of graphite surface with different technologies
- Different metals like nickel (solderable) and silver (sinterable)
- Bonding of the graphite direct to DCB (aluminum nitride or alumina)
- Silver sintering of semiconductor dies to the graphite metallization
- Soft soldering of semiconductor dies to the graphite metallization

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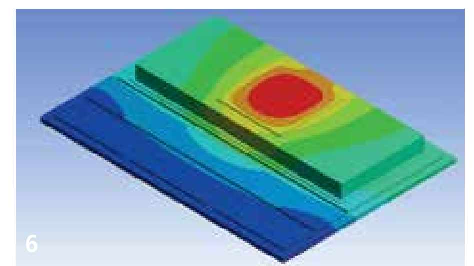
Testing

- Shear testing to characterize the graphite metallization
- Thick wire bonding to characterize the surface
- Measurement of the thermal behaviour, static (R_{th}) and dynamic (Z_{th})
- Measurement of the electrical performance
- Life time characterization of packaged semiconductor devices (active power cycling till end of life)
- Life time characterization of the material stack in terms of environmental conditions (humidity, temperature, etc.)

Graphite material properties

- Coefficient of thermal expansion (CTE) below 5.10^{-6} 1/K perfectly matched to low CTE base plate materials such as AlSiC or AlN insulating substrates and semiconductor dies like Si, SiC, GaN
- Thermal conductivity (λ) approx. 100 W/mK



2 *Metallized graphite*

3 *Graphite as base plate material*

4 *IGBT on heatspreader during power cycling test*

5 *Cross section of heatspreader bonded to DCB substrate*

6 *Thermal simulation of heatspreader design*