Elastomers for Control of Wafer Temperature in the <50°C Range During High Dose Ion Implantation

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Juergen Kusterer & **Karl Zotter**, Texas Instruments, Freising, Germany

Michael I. Current, Current Scientific, San Jose, CA USA

1. Heat transfer in spinning wheel platens
2. In-situ sensors
3. "Eskimo" Elastomers
4. Bipolar gain shifts with implant temperature
5. Summary

Heat Transfer in Spinning Wheel Platens

In 1-D*:

dQ/dt =Σ {−K*A*(ΔT/ΔX)}

where:
dQ/dt = heat flow per unit time.

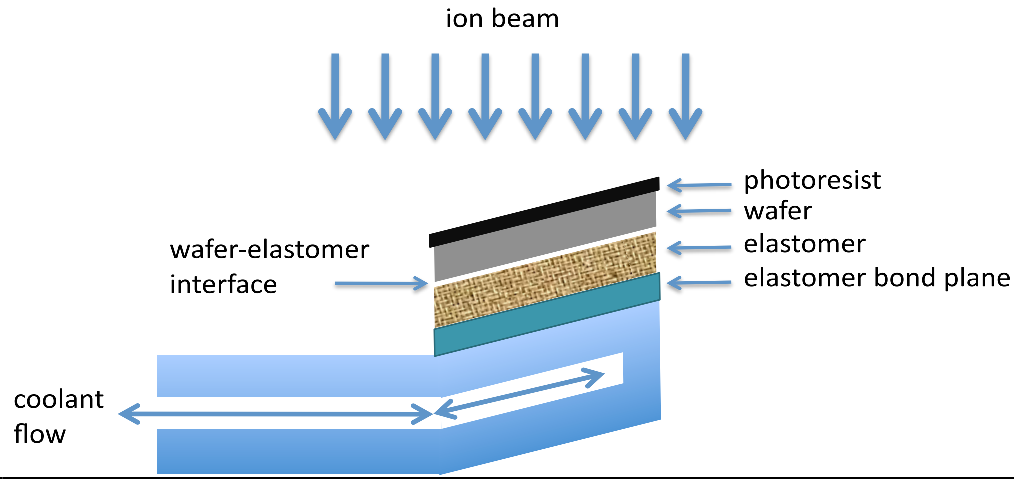
Σ{−K*A*(ΔT/ΔX)} = sum through the stack of layers and interfaces from the wafer to the coolant flow region in the wafer mount.

κ (W/m-K) = heat conductivity of each layer and interface.

A (m^2) = conducting area.

ΔT (K) = temperature difference across an interface or a layer of thickness ΔX (m).

*** Ignoring here:**
complex heating cycles for various beam power densities & scan rates, wafer clamping forces, 2D heat transfer uniformity, coolant temperature & flow rate.



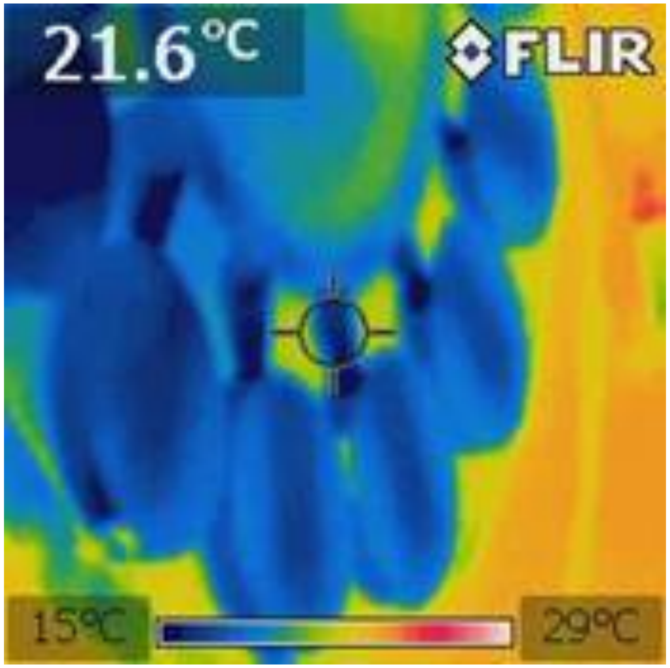
Structure	Thickness (um)	κ (W/m-K)
Resist layer	1	0.2-0.3
Si wafer	725-775	149
Elastomer	75-300	0.4

The major controllable factors in the heat transfer from the ion beam to the coolant flow are:

(1) the wafer/elastomer contact area

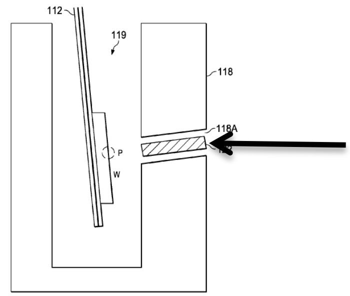
(2) the elastomer heat conductivity.

IR-Temperature Sensors

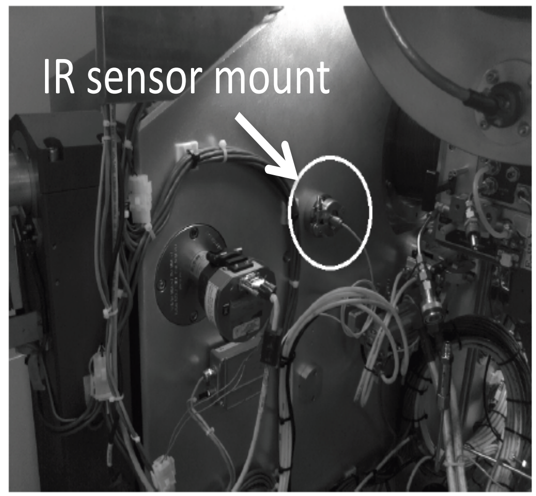


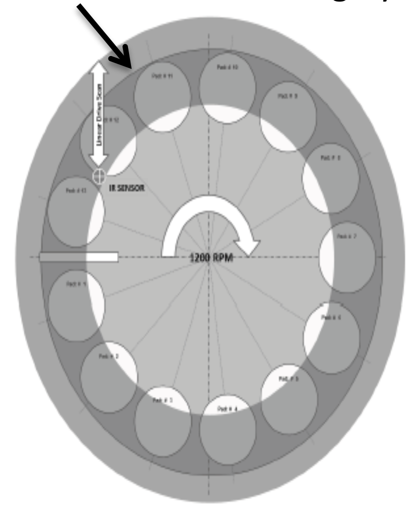
FLIR sensor image of wafer wheel temperatures, with a chiller flow at 13 C, during early stages of cool down.

Note cooler wafer pad regions along center radial regions with higher heat conductivity over the coolant flow path.



8-14 um
3 ms

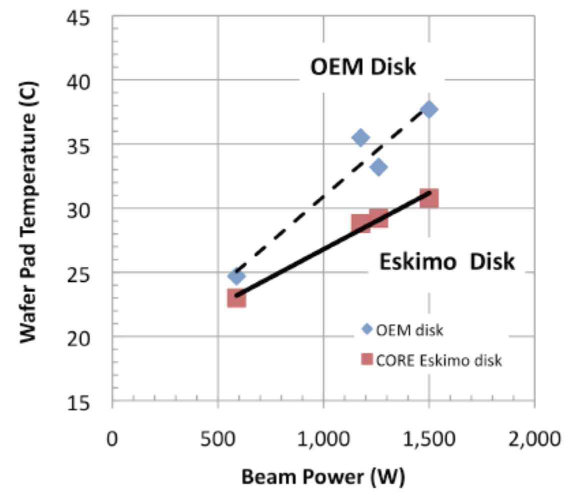


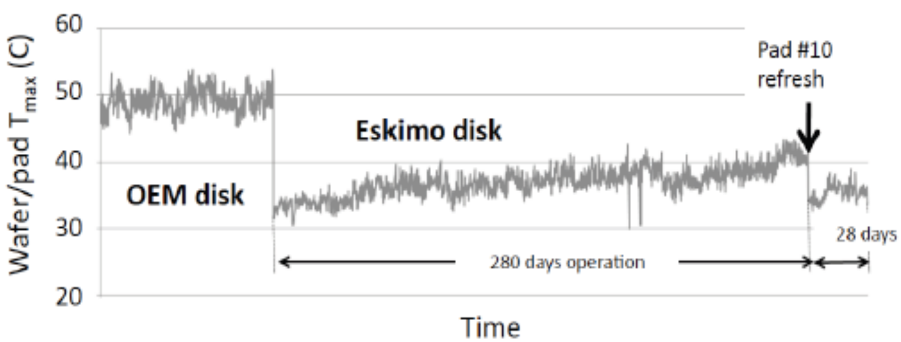


An in-situ IR sensor provides dynamic measures of the wafer/pad temperatures during and directly after high power implants .

"Eskimo" Elastomers

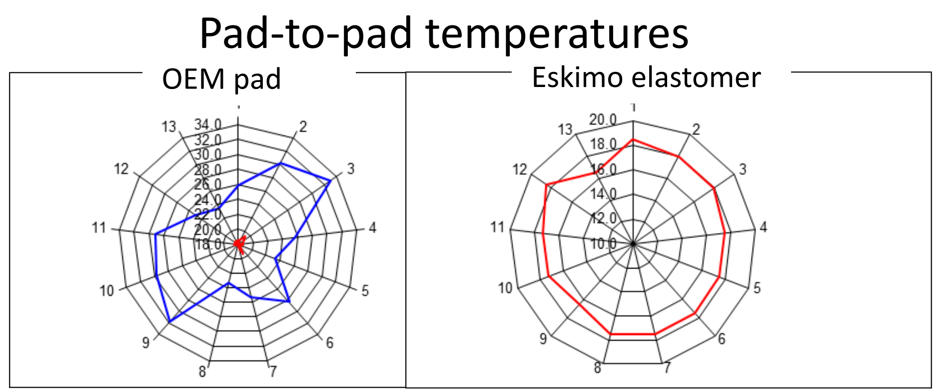
Optimizing elastomer heat conductivity, while maintaining efficient heat transfer at the wafer/pad interface, results in a >15 C improvement in peak wafer/pad temperature for a 1.2 kW beam.





Long term measurements of maximum wafer/pad temperature show sharp drop for a 1.2 kW beam after installation of an improved elastomer pad, nick-named "Eskimo".

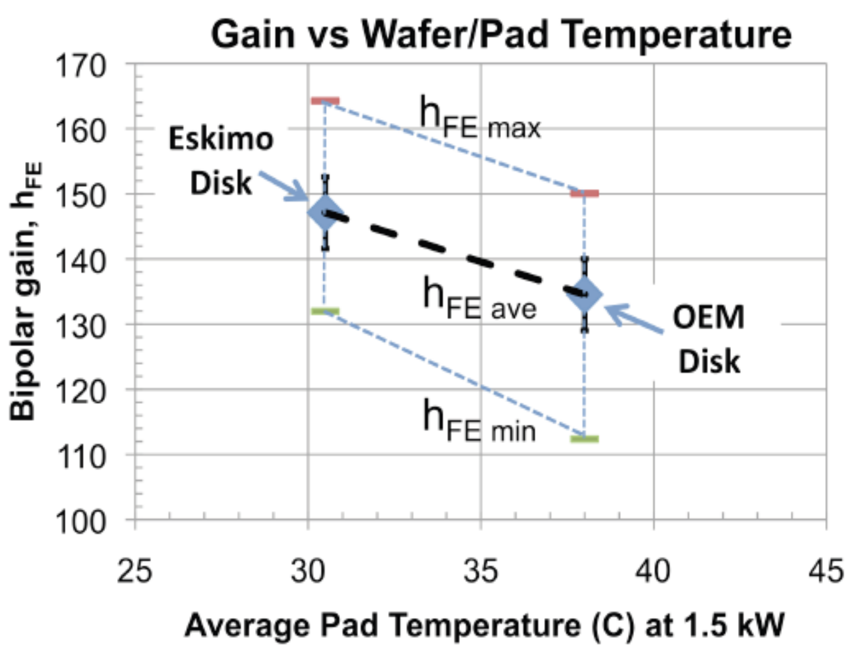
Refresh of a single pad exposed to beam uv for 280 days restores overall low temperature performance.



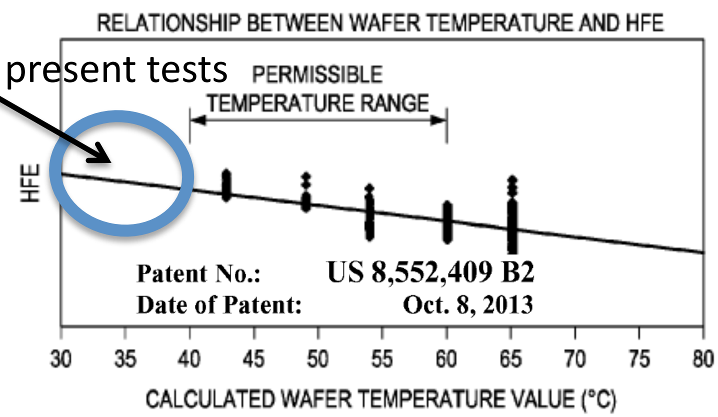
Measured average wafer/pad temperatures at various beam powers and pad-to-pad uniformity directly after high power implants show improved performance for Eskimo elastomers.

Bipolar Gain Shifts with Temperature

Bipolar transistor implants with the Eskimo elastomer disk resulted in a 9% gain increase at <30 C.



Additional TI data indicates a linear dependence on implant temperature from 30 to 65 C.



WAFER TEMPERATURE CORRECTION SYSTEM FOR ION IMPLANTATION DEVICE

Applicant: **Texas Instrument Incorporated,** Dallas, TX (US)

Inventor: **Kazuhiro Kandatsu**, Tsukuba (JP)

Bipolar transistor implants:

Dose: 3e15 to 1.2e16 ions/cm^2

Energy: 60 to 150 keV

Power: 588 to 1,500 W

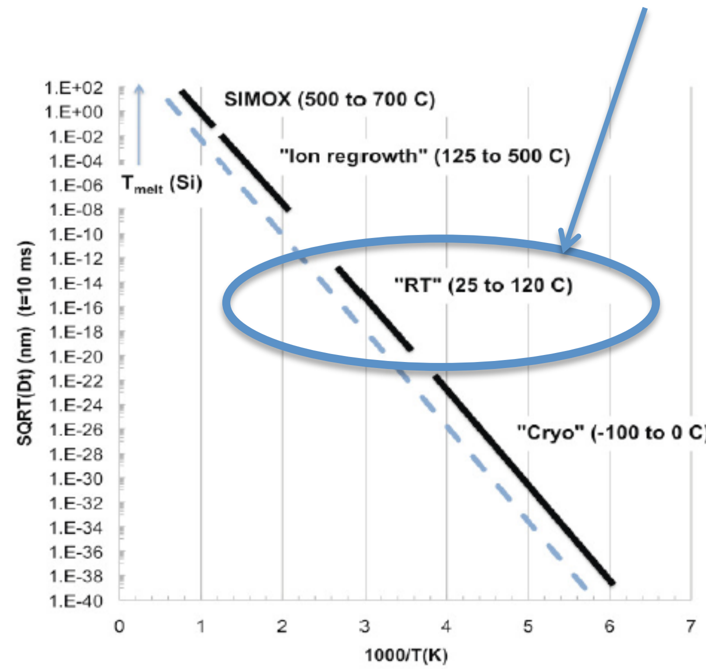
Summary

1. **Bipolar gain performance improves as wafer/pad temperatures during high power implants are kept close to "room temperatures" by use of high heat conductivity elastomer pads.**

2. **Bipolar gain (defect-related carrier lifetime & mobility scattering) variations imply similar implant temperature sensitivities near ≈25 C for CMOS drive currents (and perhaps other properties).**

3. **Improved heat sinking capabilities (elastomers, etc.) are needed for process controls and device performance enhancement.**

Range of need for *precision control of wafer temperature* during implants for control of device properties (bipolar gain, CMOS drive current, etc.)



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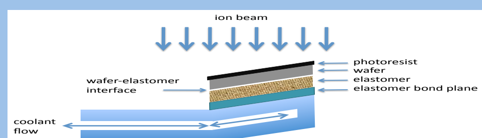
Abstract– **Wafer/pad temperatures are measured for various elastomer materials for control of wafer temperatures during high-power implantation to less than 40 C. Wafer/pad temperatures during and directly following implant are monitored by in-situ IR sensors and tracked over long operational cycles. Beneficial effects of wafer temperature control is noted for gain characteristics of modern IC devices.**

Keywords—elastomers, heat transfer, high power implantation, IR wafer temperature sensing.

The major controllable factors in the heat transfer from the ion beam to the coolant flow are (1) the wafer/elastomer contact and (2) the elastomer heat conductivity.



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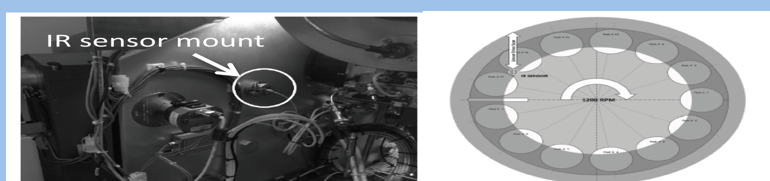

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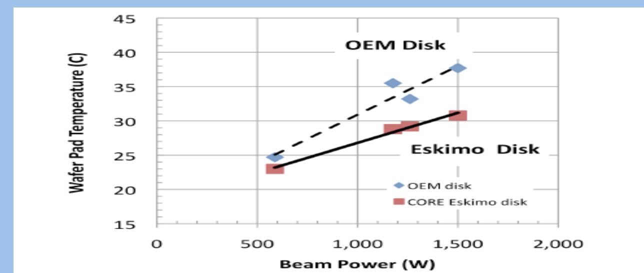

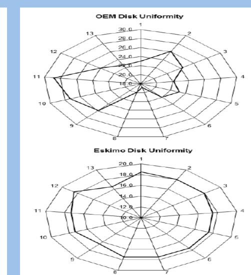

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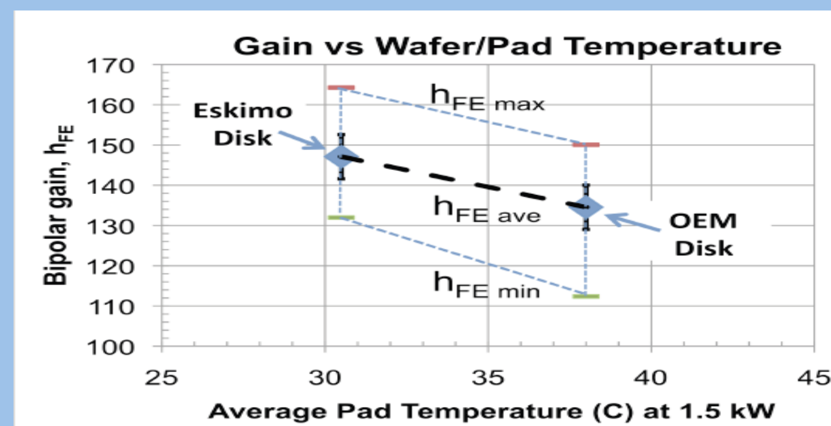

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