Temperature properties of the SVD2 hybrid

12/18/2001 SVD2 progress meeting

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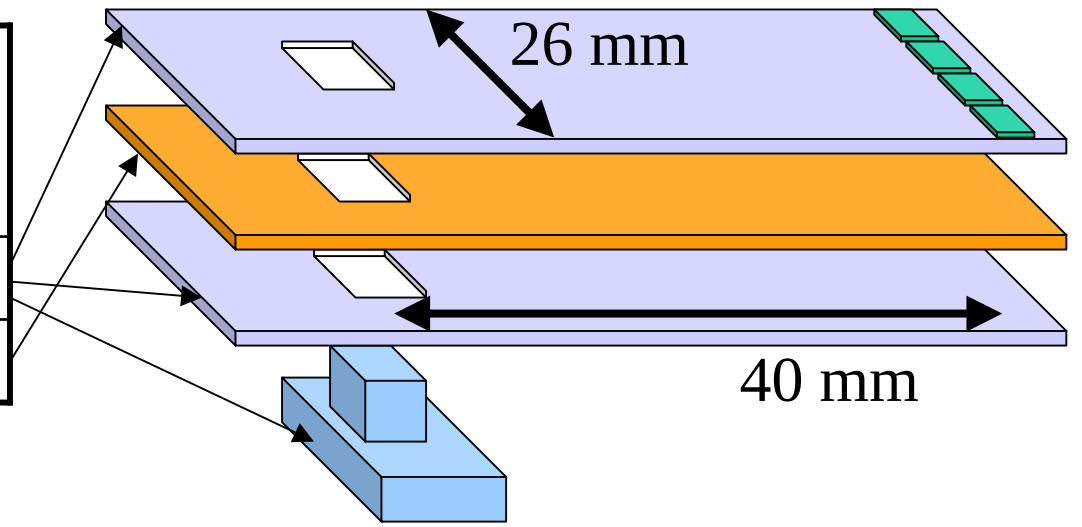
The SVD2 hybrid

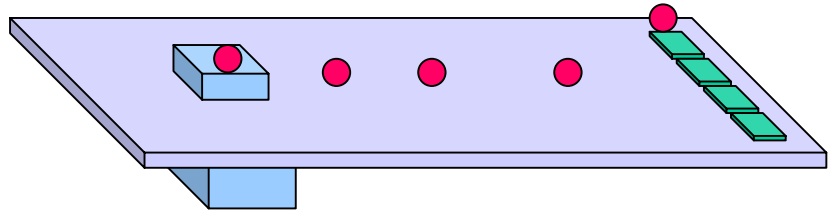
- Four VA1TA chips are mounted on a 0.5 mm-t substrate made of aluminum nitride (AlN).
- Two substrates are glued back to back over a 0.5 mm-t cupper plate (*heat spreader*).
- Heat is transferred to the cooling system through an AlN block.
- Power consumption: *P*=4 W
  - 4 mW/channel. → *P*=4 mW * 128 * 4 *2 = 4W

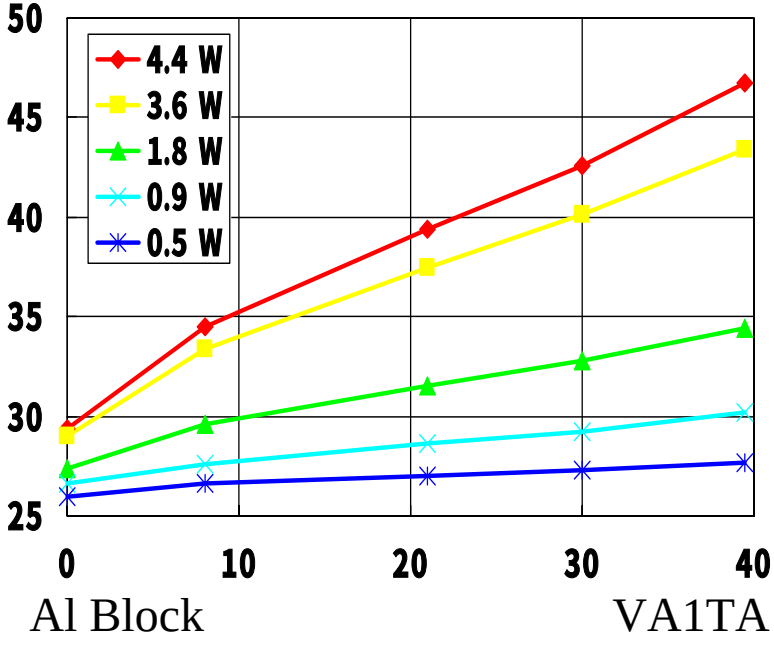
Material	Heat conductivity (W/Km)
Al N	150
Cupper	399

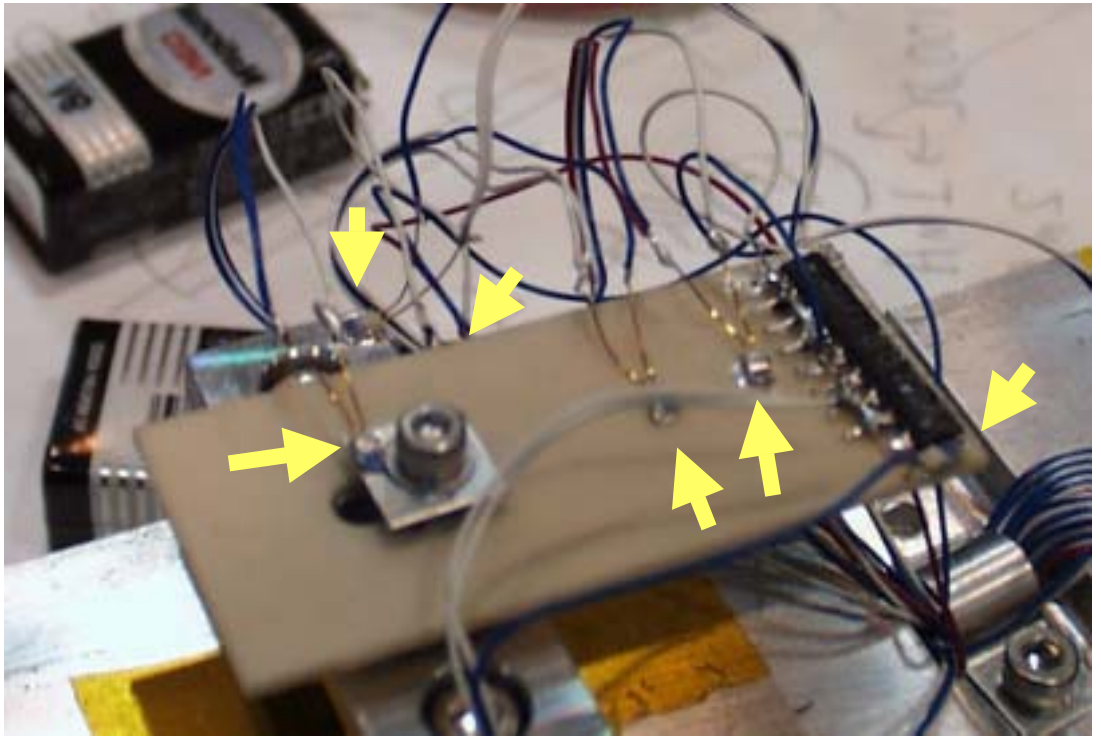


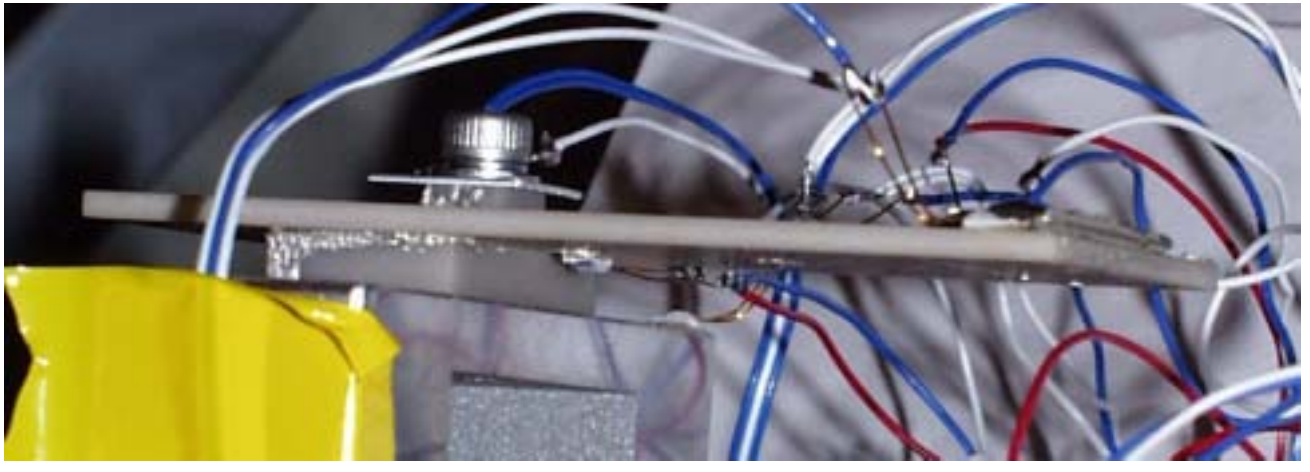
Measurement

- A mockup hybrid made of 1.5 mm thick Al-N is tested.
- A Resistor is glued as a heater.
- Temperature sensors were glued at 0, 8, 21, 30, 40 mm away from the AlN block.
- The resistor was heated up from 0 to 4.4 W
- The horizontal axis shows the position of RTD, the vertical axis shows the measured temperature.









Calculation

- A simple 1-dimensional heat-conduction calculation:
- $.\Delta T(x) = P/\lambda * x/S$
  - $.\Delta T(x)$ --- temperature of the heat sink at position x,
  - $.\Delta T(0) \equiv 0$ ---Temperature of the air and the heat sink,
  - P --- Heat Power at heat sink end,

  λ --- Heat conductivity, x --- position, S --- cross section of heat sink.
- Temperature rise for the measurement and calculation is compared at the VA1TA position (x= 40 mm).

	P (W)	λ (W/mK)	$\Delta T(40)$ (C)
Experiment	4.4	150	20
Calculation	4.4	150	36

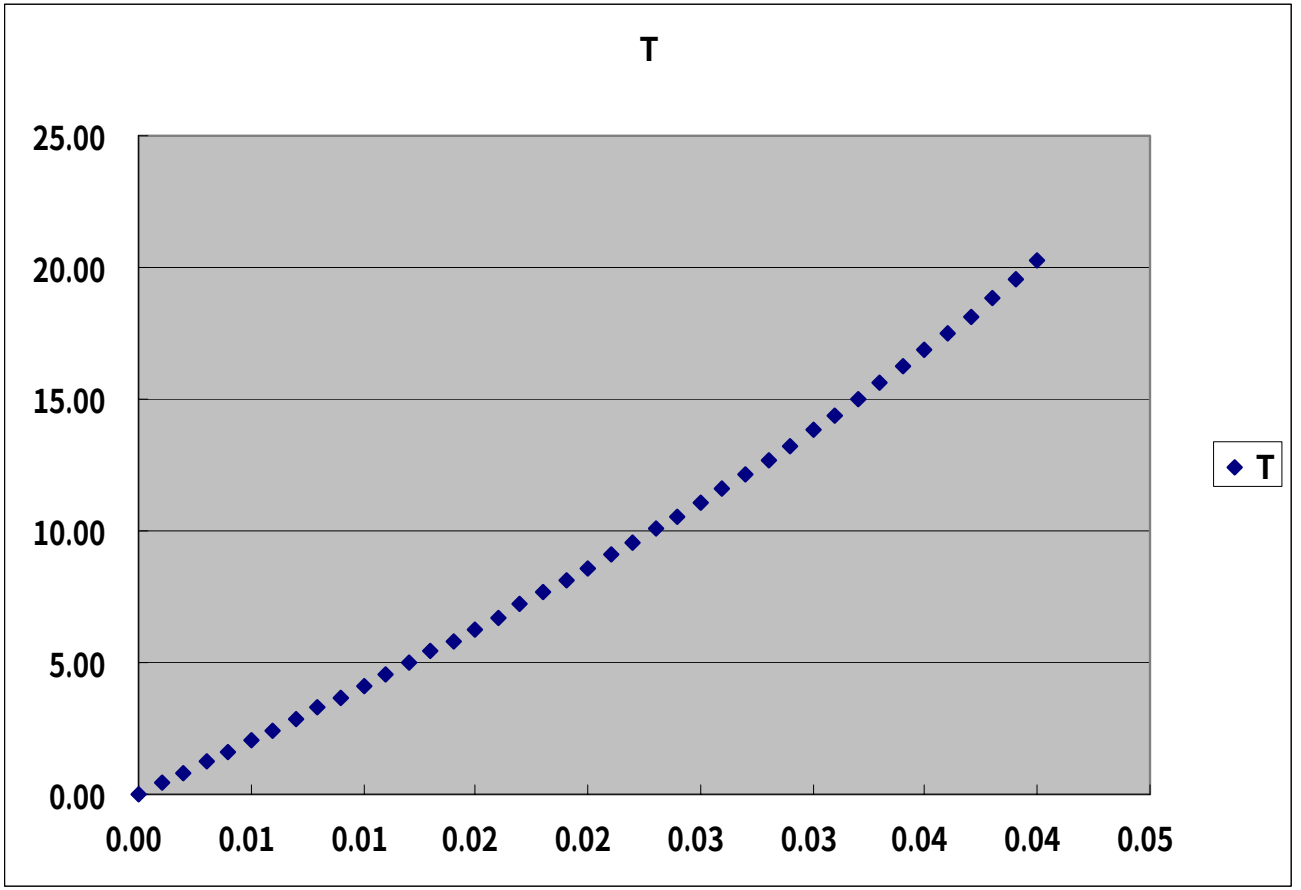
Adding a term for heat transfer to air

- The discrepancy is explained with the heat transfer to air by radiation and convection. The simplest assumption is
- $dP/dx = -\alpha\, \Delta T(x)$
  - Here α is a coefficient for the heat flow into air.
  - Heat power P is not constant but a function of x.
- We get
  - . $\Delta T(x) = P(0)\kappa/\alpha \sinh(x\kappa)/\cosh(x_0\kappa)$, where $\kappa = (\alpha/\lambda S)^{1/2}$
- The coefficient α is determined so that the experiment and the calculation match.

	P (W)	λ (W/mK)	α (W/mK)	$\Delta T(40)$ (C)
Experiment	4.4	150	-	20
Calculation	4.4	150	0.0	36
			7.2	20

Graph

- Temperature rise vs. distance from the AlN block.



Extrapolation to AlN-Cu-AlN structure

- The real hybrid will be made of two 0.5-mm thick AlN substrates and a cupper plate for better thermal conduction.
- The same value for the heat transfer coefficient to air, α, is used since it should be independent of the material inside.

	Material thickness (mm)		Effective heat conductivity λ (W/mK)	α (W/mK)	$\Delta T(40)$ (C)
	AlN	Cu			
Measurement	1.5	0	150	---	20
Calculation	1.5	0	150	0	32
				7.2	20
Calculation	1.0	0.5	230	0	22
				7.2	15

Summary

- A SVD2 hybrid consumes about 4 W of heat.
- Owing to the heat spreader, the temperature increase with respect to the heat sink temperature is estimated to be ~15 C at 4.4 W.
- An additional increase of 3 C in the AlN block and at the substrate-AlN block border.
- Effect of glue between AlN and Cu plates should be evaluated with the real hybrid, which will be delivered soon.
- The hybrids and sensors are thermally insulated, therefore, the hybrid temperature is not an important issue compared with all the other problems.
  - Nothing to do if the temperature is higher than expected.