

Radiation effects on the “CERN_Bandgap” circuit

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The CERN_Bandgap circuit has been developed within the Microelectronics group in 2000 as analog building block in the CMOS6SF technology. As such, it uses radiation tolerant layout techniques. The diodes used to generate the reference voltage have been laid out using the only layout recommended by IBM for forward-biased diodes.

Irradiation tests performed with the CERN X-rays facility have shown at the time of developing the circuit the following output voltage drift with total dose:

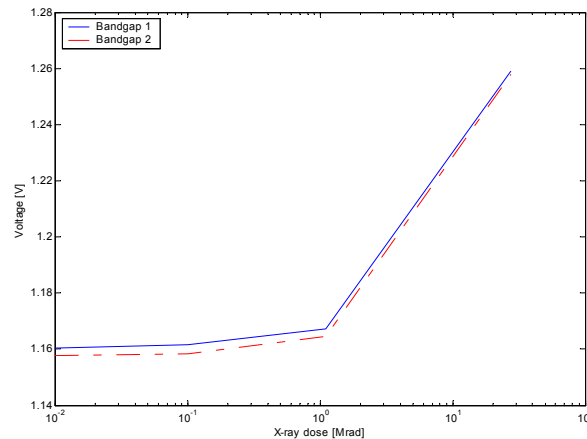


Figure 1: Output voltage drift for the bandgap integrated in MPW3 (ALTIS product, January 2001). Irradiation has been performed up to 30Mrad.

Very comparable voltage drifts have been confirmed by the irradiation of circuits using the bandgap as reference voltage generator, manufactured over a large time span (from 2000 to 2003). Users of the bandgap have been informed of this effect, which has also been presented at the User Meeting held in Imperial College on June 17, 2002, (see minutes and slides in the deep submicron web page). Most often, this has been judged as negligible for the application, in particular for use in radiation environments up to a few hundred krads.

The common point between all the above circuits was that they have been manufactured in the French ALTIS foundry, partially owned by IBM. Until end of 2002, all of our circuits have been manufactured in this facility, but IBM decided to move all new products to their Burlington Foundry at that point.

Circuits manufactured in Burlington started to be available in 2003, and we have just very recently noticed on some of these circuits that the voltage drift of the bandgap is considerably larger. A typical drift as a function of the total dose, measured again using the CERN X-rays facility, is shown in Figure 2.

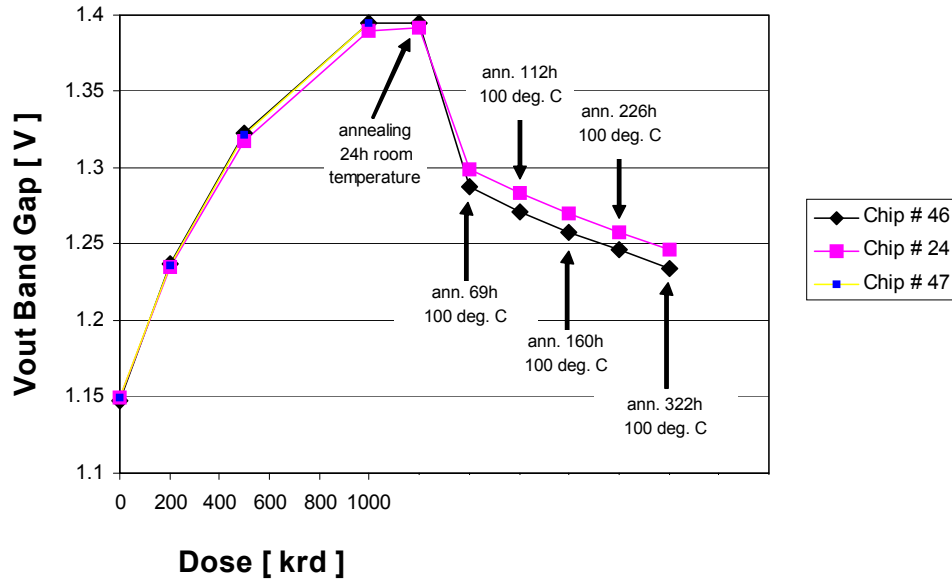


Figure 2: Output voltage drift for the bandgap integrated in MPW11 (Burlington product). Irradiation has been performed up to 10Mrad, all the following points refer to measurements during annealing as indicated in the chart.

At the end of 2003, IBM communicated that – due to a large increase of orders in the CMOS6 technology – all new “CERN products” will be built again in the ALTIS foundry. The first of such products has been our MPW12. Some of the circuits in this run used the bandgap building block, and irradiation with X-rays of several samples showed that the voltage drift is very comparable to what has always been observed in ALTIS products in the past (see Figure 3).

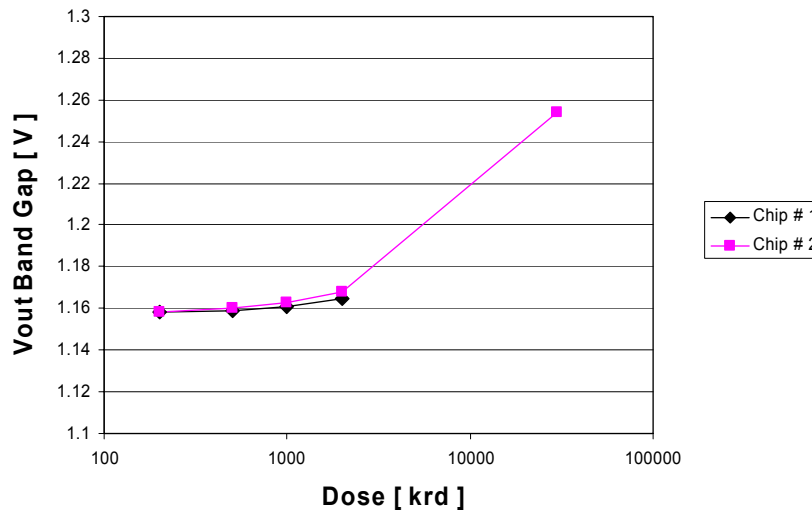


Figure 3: Output voltage drift for the bandgap integrated in MPW12 (ALTIS product, January 2004). Irradiation has been performed up to 30Mrad.

From all data collected so far, it appears therefore that:

- Bandgap circuits manufactured in ALTIS show a very consistent voltage drift over time, the drift being acceptable for most applications.
- The same bandgap circuit manufactured in Burlington shows a much more pronounced voltage drift with total dose. This might be unacceptable for several applications.