BJTs in Space: ELDRS Experiment on NASA Space Environment Testbed

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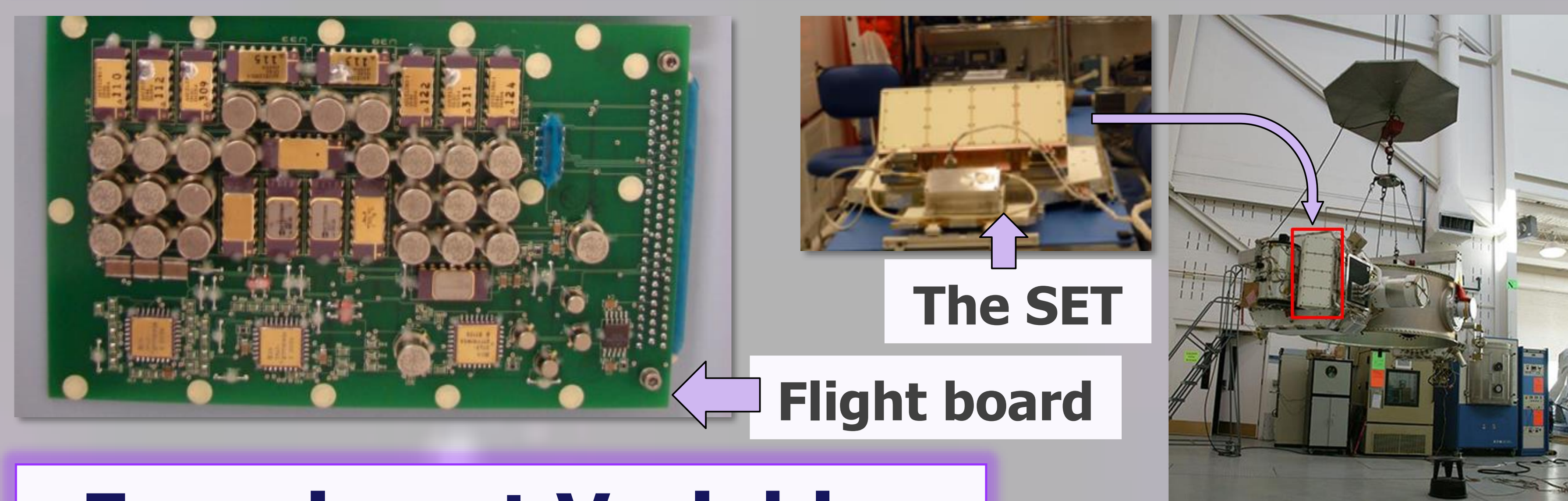
Abstract

Flight data on bipolar junction transistors (BJTs) are recorded to characterize the effect of low dose rate (LDR) space irradiation; results are comparable to ground-based LDR and elevated temperature tests. Additionally, Gummel plots of mission data are compared for different device under test (DUT) experiment variables.

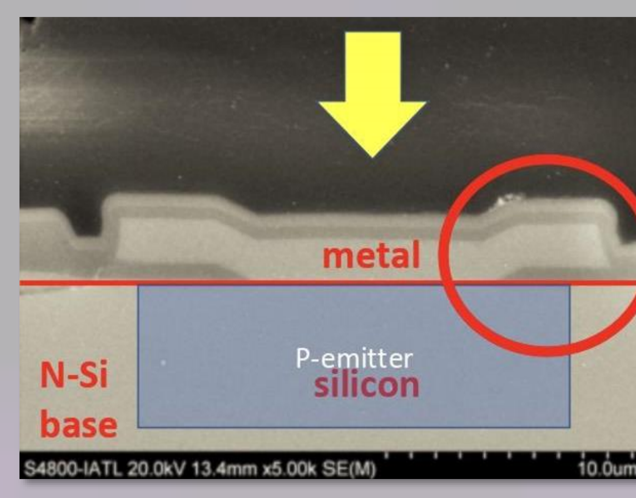
Space Environment Testbed

The Space Environment Testbed (SET) is one of several missions developed under NASA's Living With a Star (LWS) program. The "ELDRS" testbed, one of four experiments on the SET, performs real-time, in-orbit measurements of radiation-induced degradation. The "ELDRS" experiment monitors changes in BJT collector and base currents and has been acquiring data on LPNP BJTs in-flight continuously for over twenty months at an average dose rate of 0.19 mrad(Si)/s.



Experiment Variables

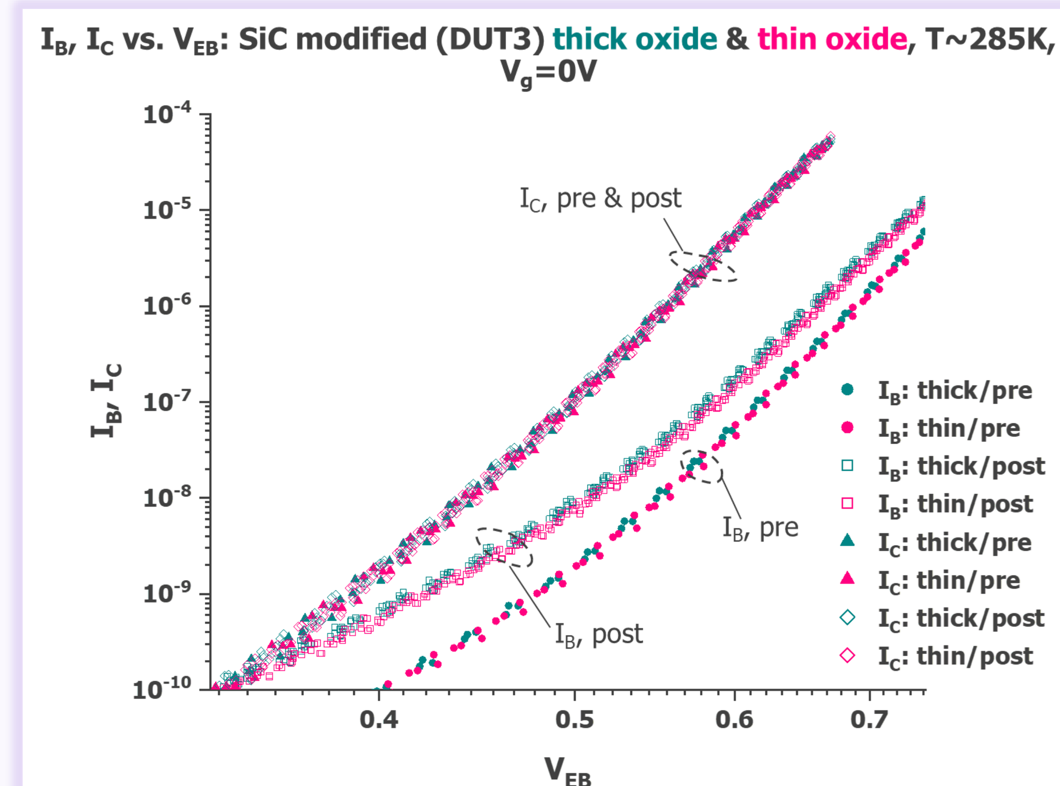
- "Prerad": 08/02/2019-08/18/2019; 0.06-0.11 krad
- "Postrad": 11/22/2020-01/06/2021; 5.65-5.79 krad
- Temperature: Each data set is within 2K of the noted temperature
- Oxide thickness: 1.22 μm, 0.56 μm
- Passivation: p-glass or silicon carbide

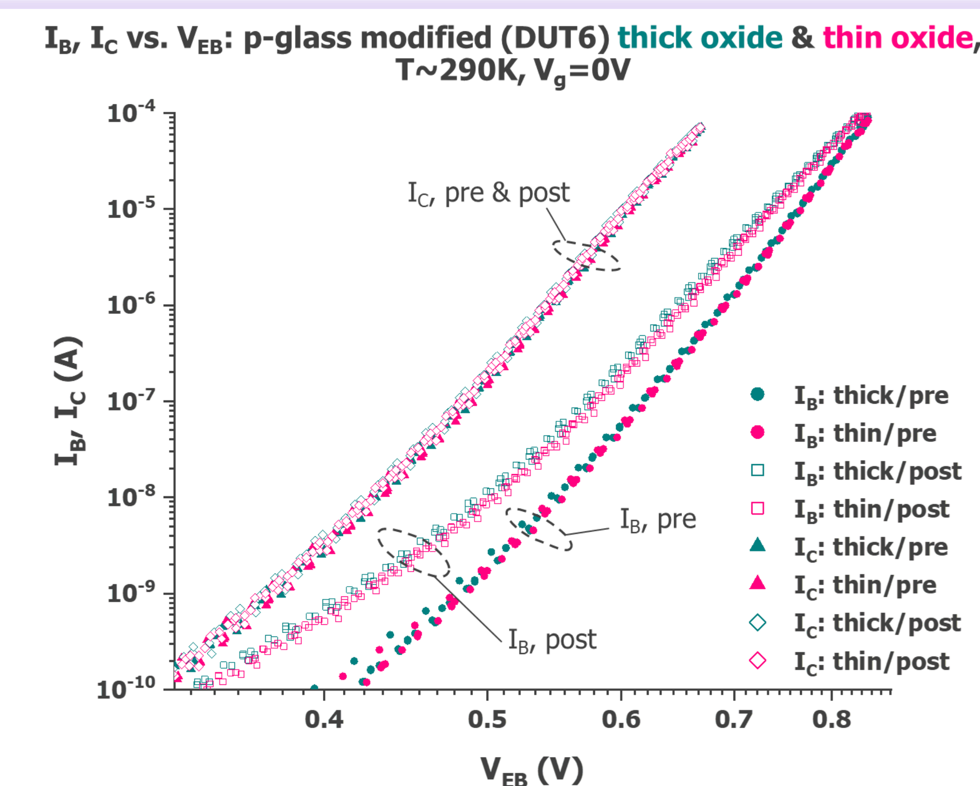


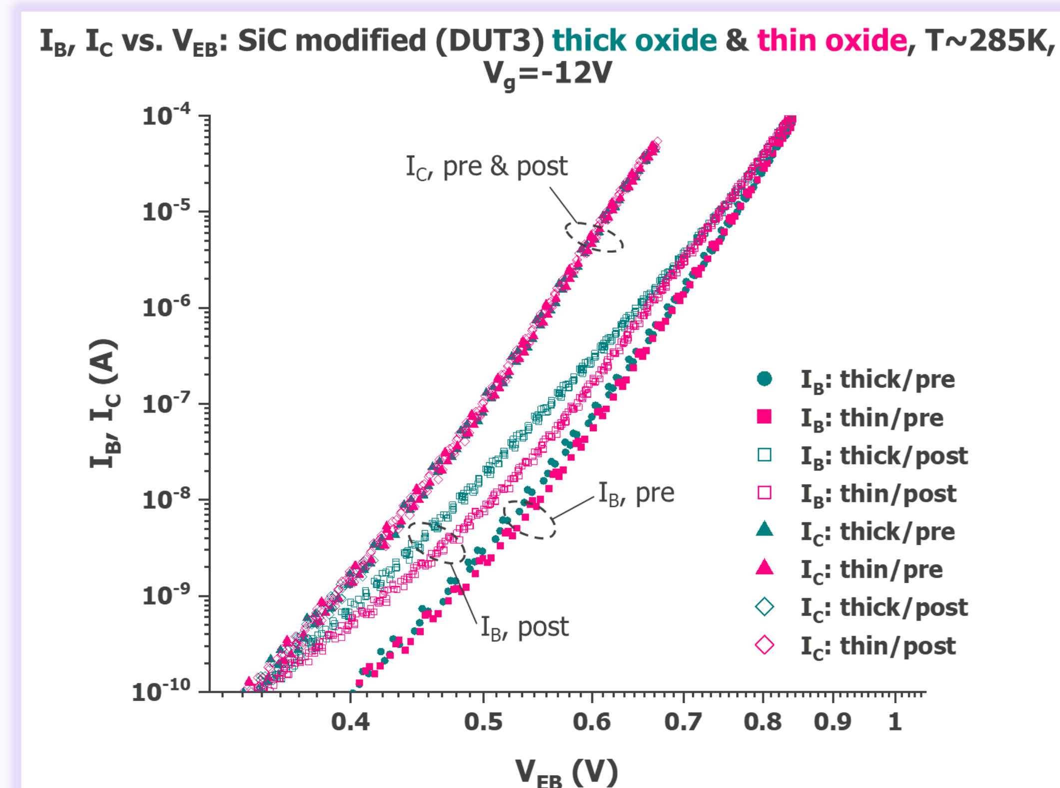
Oxide Thickness

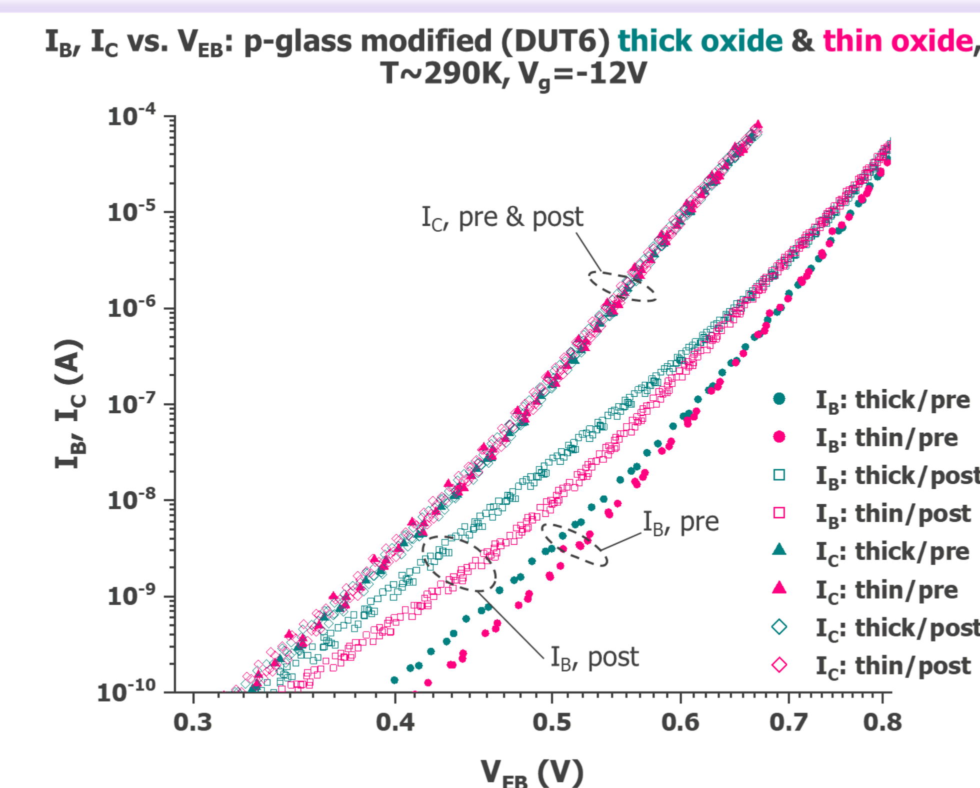
"ELDRS" Experiment: Objectives

- Characterize the space environment and better understand its impact on electronics in space
- Measure Enhanced Low Dose Rate Sensitivity (ELDRS) on BJTs in a real space environment
- Validate/improve accelerated ground test protocols for ELDRS screening
- Assess the impact of oxide thickness on radiation response









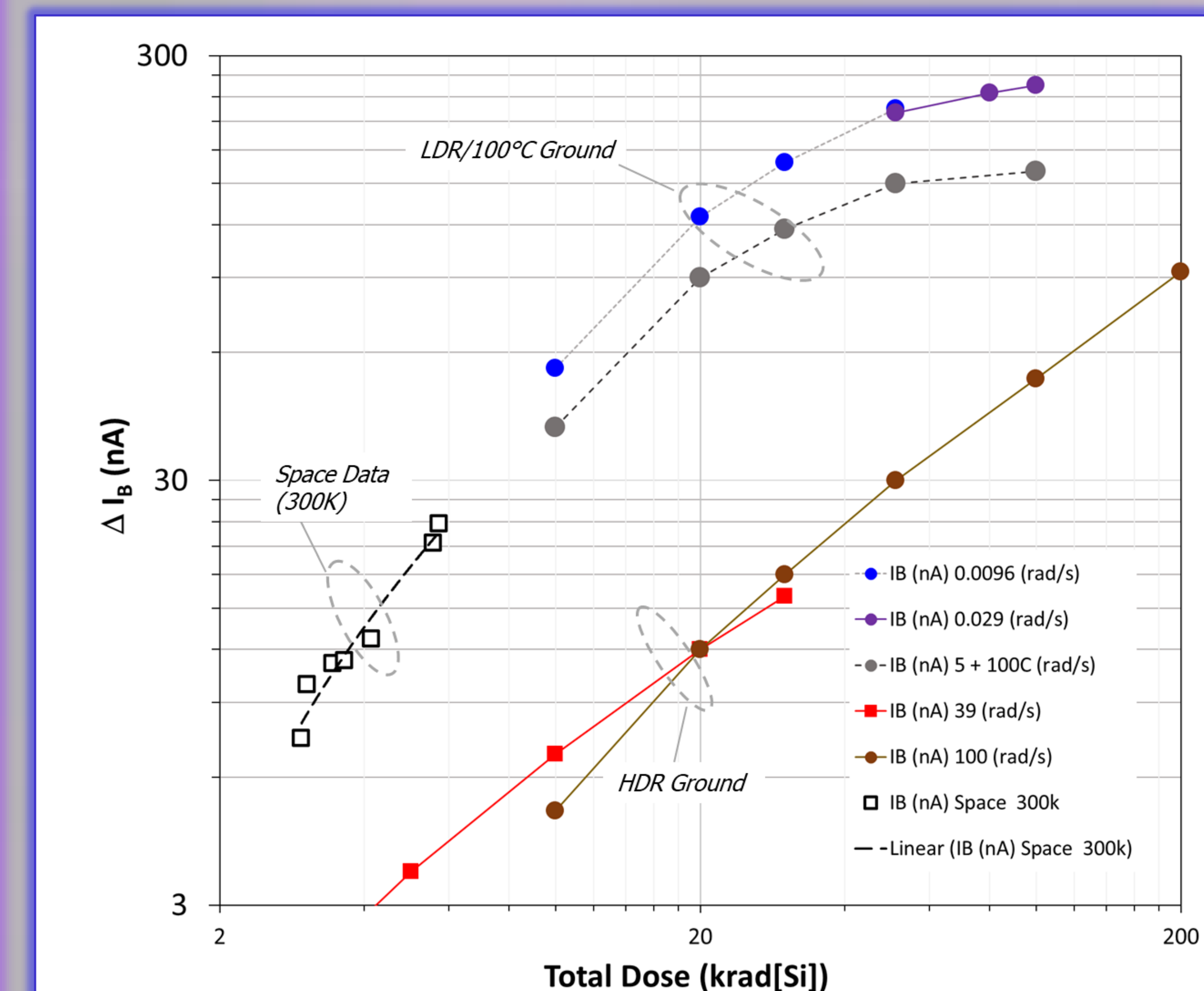
Note: As expected, BJT currents increase with increased measurement temperature during data acquisition.

ELDRS

Enhanced Low Dose Rate Sensitivity (ELDRS) is the enhancement of degradation in transistors or circuits when exposed to radiation at low dose rates as compared to high dose rates.

Excess Base Current

The excess base current vs. total dose plot (below) shows in-flight space environment data for the p-glass unmodified-package (DUT6) transistor, along with low dose rate (<30 mrad/s), elevated temperature irradiation (5 rad/s + 100°C), and high dose rate (≥39 rad/s) ground test data.



Conclusion

This experiment is the first demonstration of ELDRS on BJTs in a live mission environment. ELDRS SET data on DUT 6 (p-glass, unmodified) thick oxide GLPNP shows excess base current response at 300K and follows the response profile of low dose rate ground base data (<30 mrad/s), confirming the utility of MIL-STD Test Method 1019.6 recommendations. Thin and thick oxides for both SiC and p-glass passivated GLPNP BJTs show a difference in post-rad response, primarily for V_G = -12V.

Acknowledgements

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