Oxide Reliability

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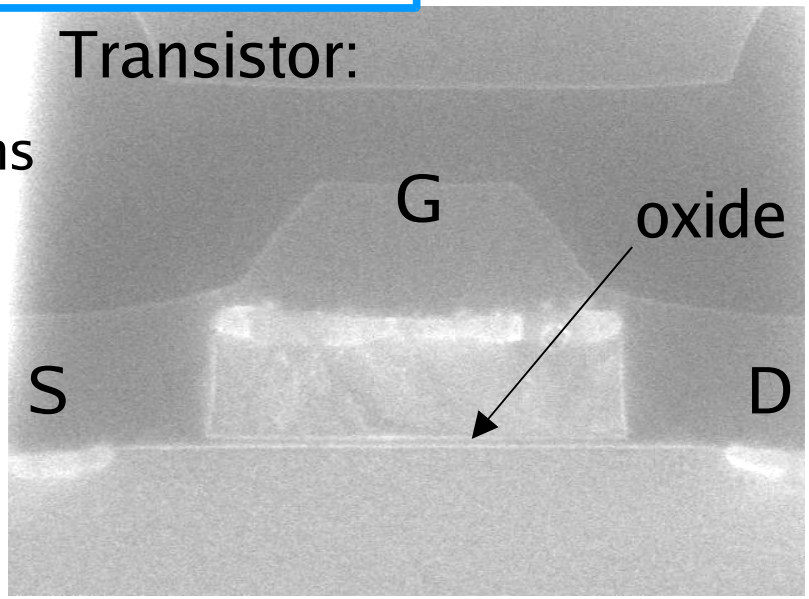
Reliability is the probability that a component meets a determined mission in a determined environment for a determined period of time.

- The challenge of reliability investigations
- The oxide under Stress
- The Weibull statistic



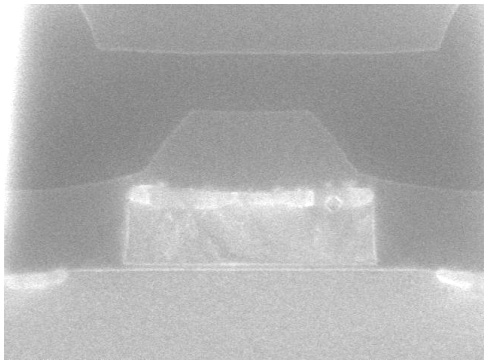
The Evolution of Transistors:

1947 : Invention of the bipolar Transistor, by
Bardeen, Brattain, Shockley.

1958 : Kilby invents the integrated circuit.

today : Pentium II, 0.35 micrometer technology,
7 500 000 transistors.

STM std. techn: $0.2 < L < 0.5$ (Micrometer)
$30 < t_{ox} < 50$ (nanometer)



The challenge of Reliability investigations:

Telephone switching system with 100 000 Transistors,
one failure per month.

$$= \frac{1\ Failure}{10^5\ Devices \times 720\ Hours} = 14 \times 10^{-9}\ \frac{Failure}{Devicehour} \approx 10\ FIT$$

For 100 Devices on Test

Failure rate	Time for 1 failure [years]
10 FIT	114
100 FIT	11
1000 FIT	1

If we run 500 devices for 6 month with no failure

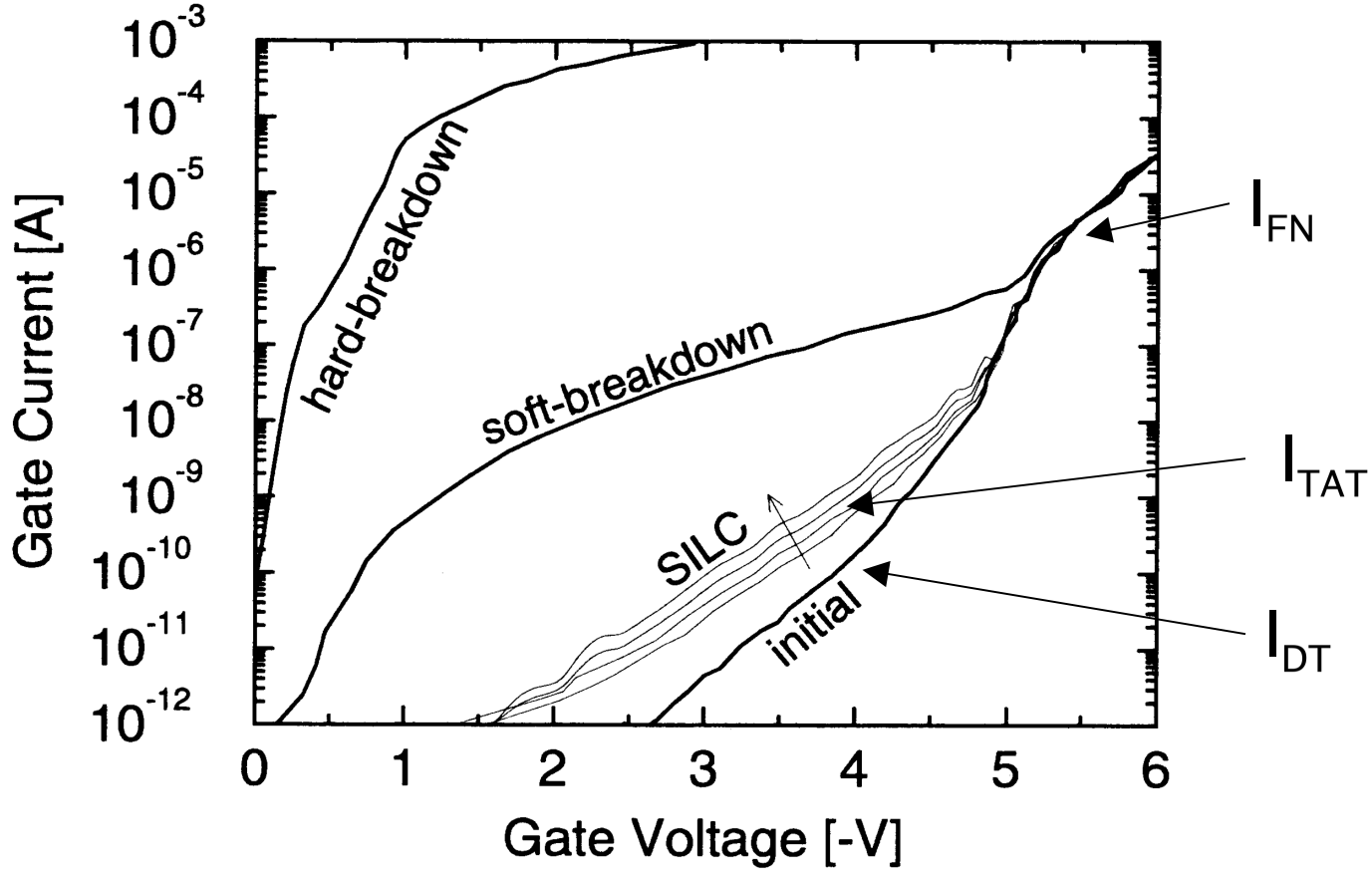
Confidence level	Failure rate
best estimate	325 FIT
60	430 FIT
90	1100 FIT

Accelerated tests are needed !

[1]A. Birolini, Reliability Engineering, Springer Verlag, Berlin 1999.

The oxide under stress

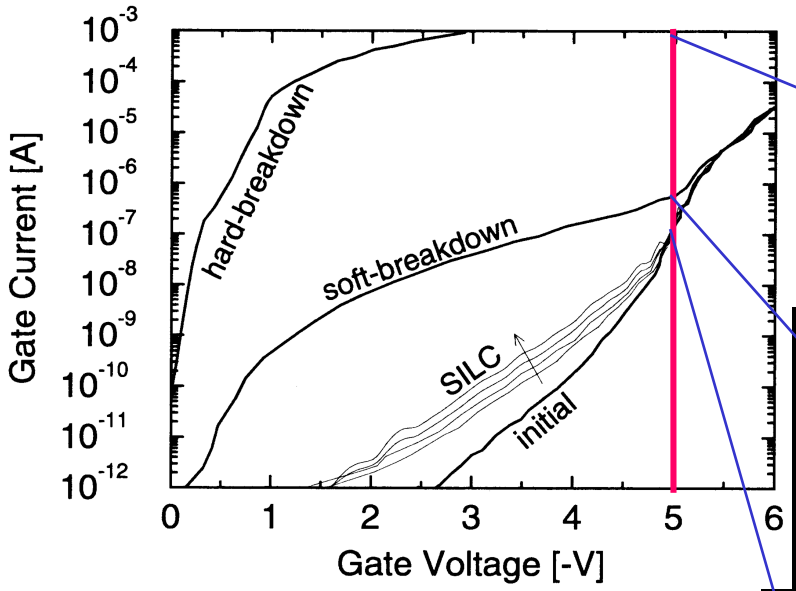
IV-curve:

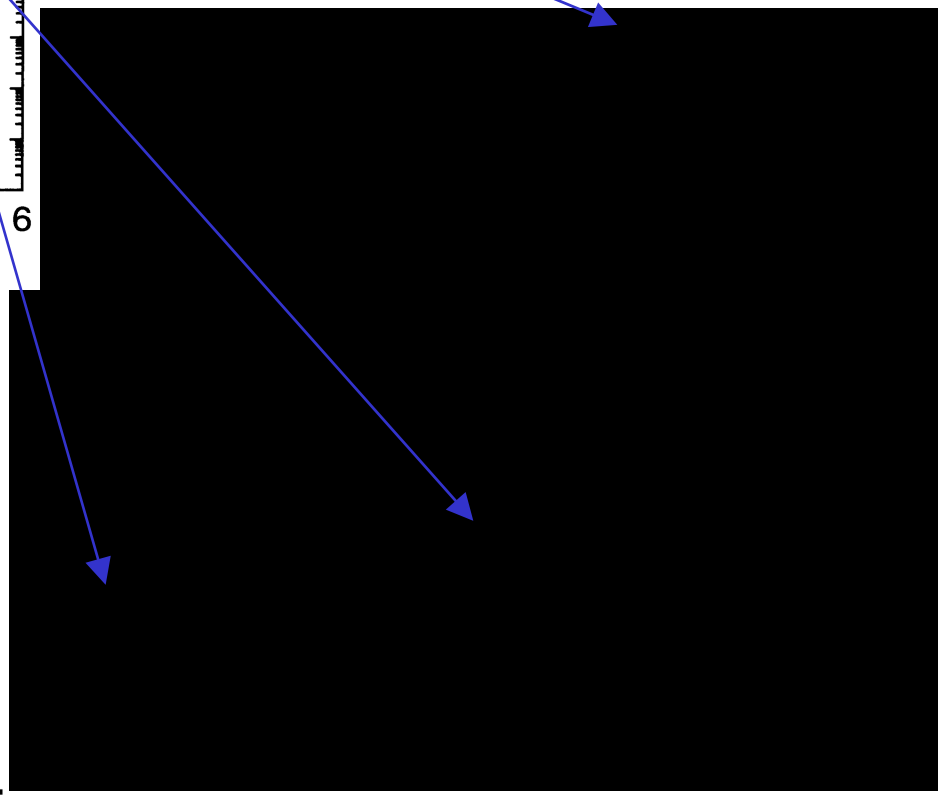


[1] K.Okada, JJAP 36, 1443 (1997).

Accelerated Test:

Constant Voltage Stress





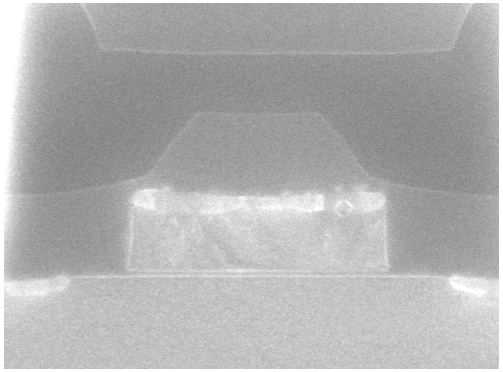
[1] K.Okada, JJAP 36, 1443 (1997).

Accelerated Test (Summary):

"After 10 years of operation at the nominal conditions (voltage, temperature) at most 100 devices per Million can be broken." [2]

Accelerated tests to reach a high percentile of failures.

To predict failure rate at working conditions:



Scaling in Area
Voltage
Temperature

You have to know the scaling laws!

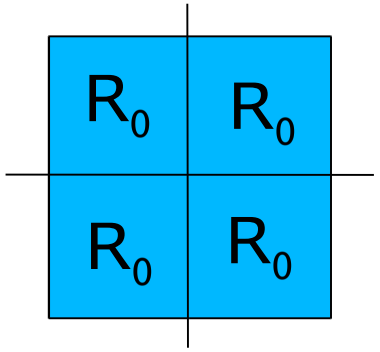
[2] International Technology Roadmap for Semiconductors 2001

e.g. Scaling in Area:

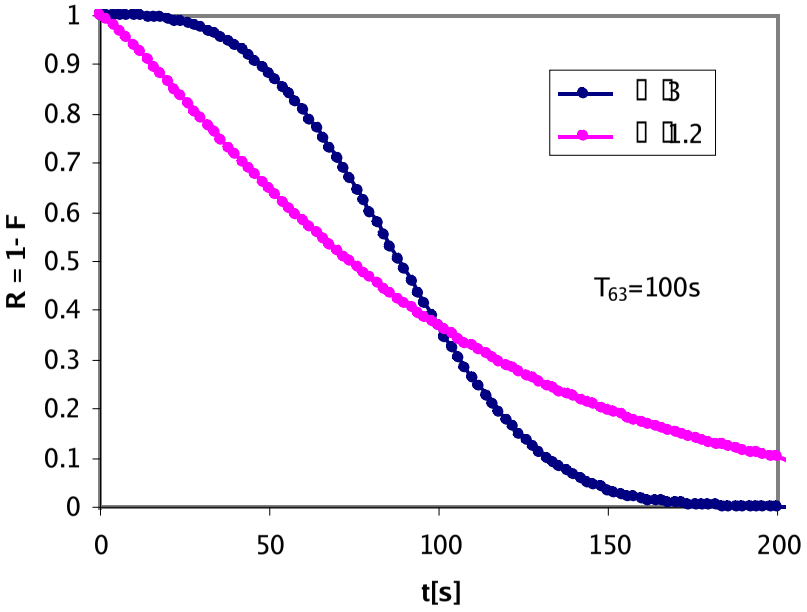
Weibull Distribution (weakest link problem)

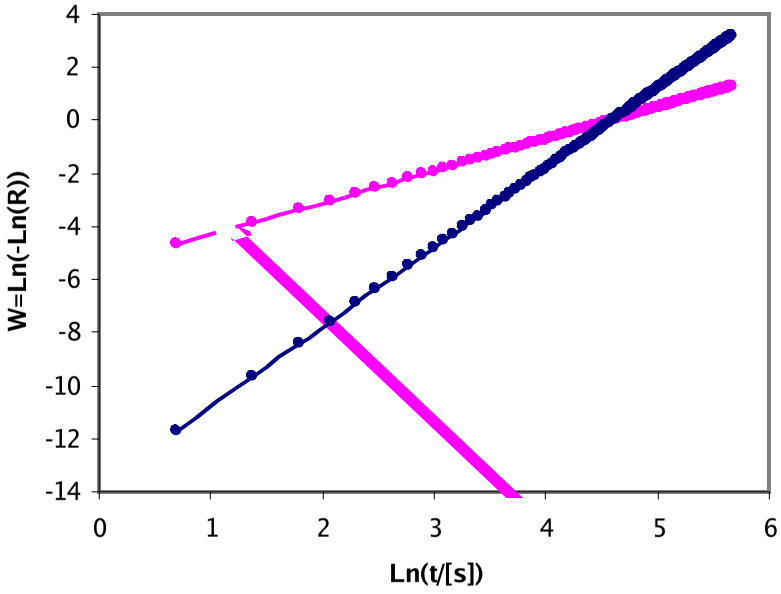
Reliability: $R(t) = e^{-(t/T_{63})}$

β: Weibull slope



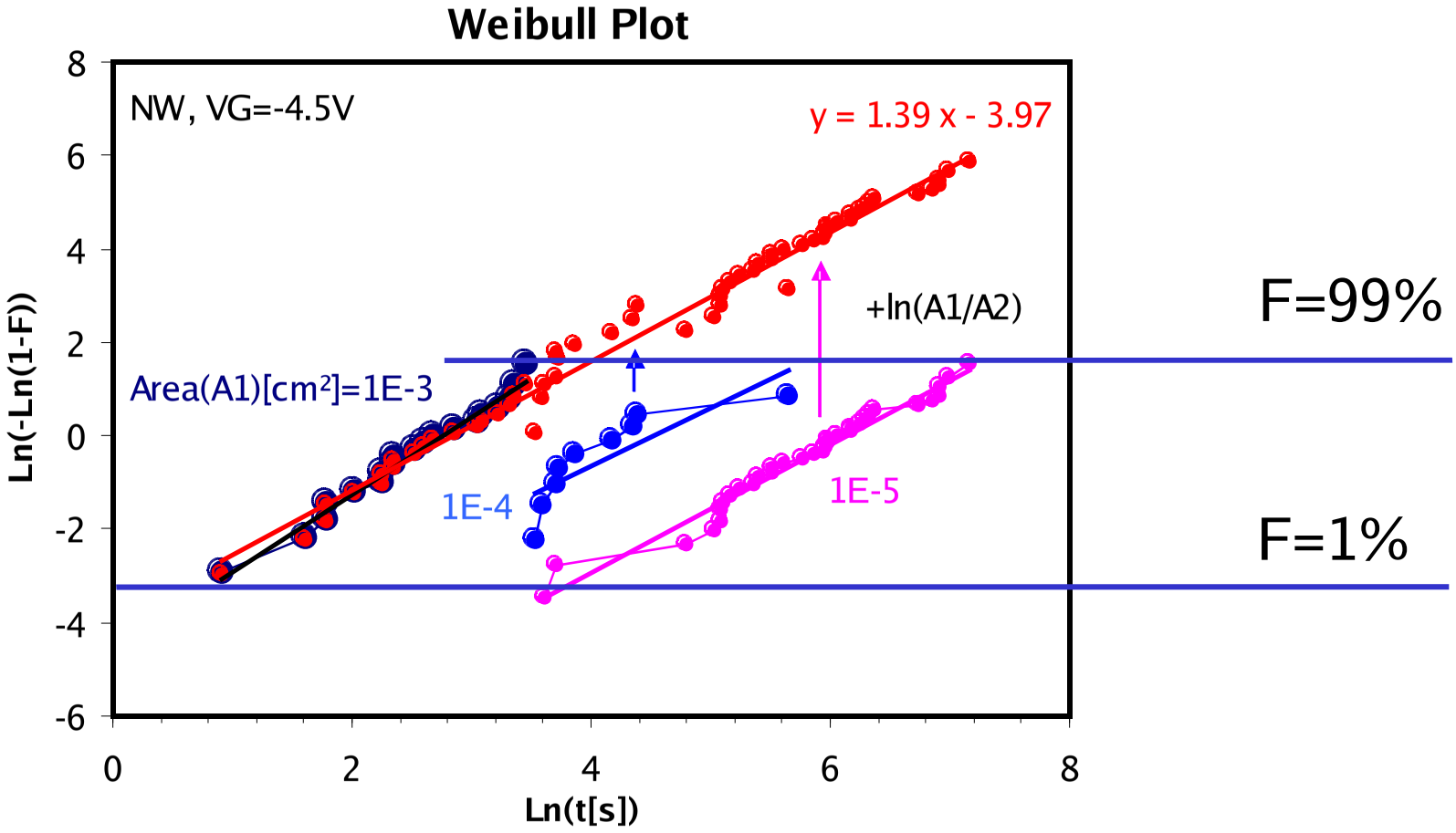
$R = R^4$





Area Scaling:

$$T_{63}(A) = T_{63_{Test}} \cdot \left(\frac{A_{Test}}{A} \right)^{\frac{1}{-}}$$



Summary:

- Estimation of life time for components is important to have a useful system.
- Accelerated tests are needed:
  e.g.: Constant Voltage Stress
  Area scaling with Weibull statistic

Literature:

VLSI Technology, edited by S.M. Sze AT&T Bell Laboratories, McGraw-Hill Book Company, Singapore 1995.

Reliability Engineering, A. Birolini, Springer Verlag, Berlin 1999.

International Technology Roadmap for Semiconductor, Semiconductor Industry Association http://public.itrs.net , 2002.