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Article

Transistors Under Influence of Humidity

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A B S T R A C T

In this paper the effect of humidity is considered on transistors. The forward current transfer ratio (h_{fe}) of transistor varies due to the absorption of moisture. The dependence of performance of p-channel of the transistors on R_H value of humidity is determined. A decrease in current output and mobility is observed.

Keywords: Forward Current Transfer Ratio, H-Parameters, Relative Humidity, Transistor

Introduction

In our everyday life we confront with many electronic elements as well as gadgets. In general, these elements may have significant effect of humidity and moisture on them. Electronic devices are exposed to harsh and variable environments and thus common reasons for non-performance in electronics are ecological contaminants and conditions as temperatures and the humidity with other factors, for example, from vibrations, ripple voltages, over voltages and corrosive effects. These all may have effect on the performance of electronic components. In the paper here the effect of humidity is decided on number of active and/or passive electronic elements. These have corrosive effects also. This corrosion effect demeans these elements when uncovered with some time and then the considered elements become useless and cannot be further used. The findings of many other researchers for the similar purpose show that combination of high humidity and temperature did not possess a considerable risk for these capacitors during their normal use. Remarkably high humidity and radical temperature changes both affected the breakdown voltages of tantalum capacitors. Salt fog caused corroding of these active and passive components and had a small effect on breakdown voltages but did not have any effect on capacitance or ESR.[1]

The effects of moisture on the electric characteristics of pentacene Field-Effect Transistors (FETs) with the Poly Vinyl Pyrrolidone (PVPy) gate insulator were observed. For the relative humidity below 40%, the pentacene FET showed a stable operation without a shift in the threshold voltage upon a gate voltage sweep direction. With rise of the relative humidity above 50%, the threshold voltage shifted critically towards the positive direction, accompanied by considerable degradations in the field-effect mobility and the sub-threshold slope. These moisture-induced characteristic degradings could be substantially recovered by the low-temperature annealing processes under a base pressure of 2×10 Torr.[2] In another experiment, the organic field effect transistor was constructed on a thoroughly cleaned glass substrate, in which the junction between the metal gate and the organic channel was made to play the role of gate dielectric. Thin films of organic semiconductor Copper Phthalocyanine (CuPc) and semitransparent Al were deposited in steps by vacuum techniques on the glass substrate with pre-deposited Ag source and drain electrodes. The output as well as transfer characteristics of the constructed device were performed. The effect of humidity on the drain current, drain current-drain voltage relationship and threshold voltage was determined. It is observed that humidity has a strong effect on the characteristics of the organic field effect transistor.[3] Various effects of moisture exposure on radiation-induced degrading of both MOS transistors and ICs constructed in older technologies (e.g., vintage mid-1980s with gate

lengths of 2 µm and larger)are explored.[4-6] Results of the works have shown some impact of moisture exposure on radiation hardness and have predicted that moisture-related aging effects may be significant for electronic systems in radiation environments. [4-6] In the domain of printed electronics, Field-Effect Transistors (FETs) with oxide semiconductor channel are very promising. In practice, the use of high gate-capacitance of the composite solid polymer electrolytes as a gate-insulator checks extremely low voltage requirements. The experimental results of the electrolyte-gated FETs (demonstrate rather corresponding currents between humidity levels of 30%-90%. However, the shifted transistor parameters lead to a considerable performance change of the frequency behavior.[7]In various applications, certain electronic equipment may contain highly devices sensitive pertaining to rigorous environmental conditions. Understanding the effects of these unpredicted environmental conditions at the component as well as system levels and on applying this knowledge in designing phase can improve the performance of the equipment, thereby reducing failures and dropping maintenance costs.[8]

Theory

The forward current transfer ratio, h_{fe}, which stands for h-forward-emitter is directly related with the performance of the transistors. H-parameters are used for small signal frequency analysis and determine the system performance by calculating the output gain. h_{fe} is the ratio of output to input in the common emitter configuration, which in turn means it is the ratio of collector current to base current, which is basically the gain of a bipolar transistor.

Experimental Description

Preparation of Solution

Specific Gravity of H_2SO_4= 1.84 gm/ml.

- For RH=60%, 38.35 gm percentage i. e. 104.2 ml H_2SO_4+395.8ml distill water
- For RH=90%, 11 gm percentage i. e. 29.9 ml H_2SO_4+470.1 ml distill water

We recorded the forward current transfer ratio, h_{fe}, of PNP and NPN transistors using LCR Circuit Kit at relative humidities RH=60% and RH=90% for a few days. The variation of h_{fe} is tabulated in tables-

Table 1.Variation of h_{fe} of NPN Transistor vs Time at RH = 90%

Days	h_{fe}
0	216
6	213
13	214
26	213
61	209

Table 2.Variation of hfe of PNP Transistor vs Time at RH = 60%

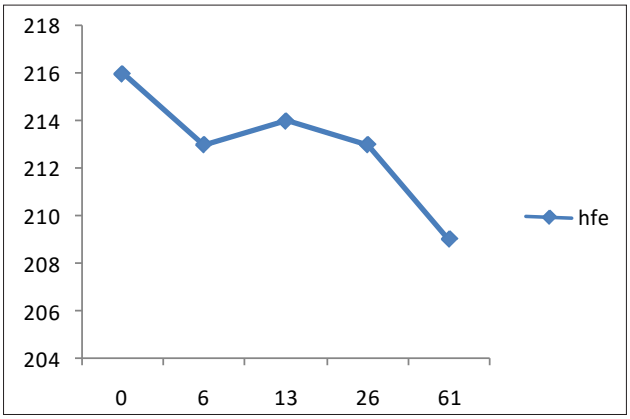
Days	h_{fe}
0	62
6	61
13	61
26	60
61	59

Discussion of Result

The graphical variation of h_{fe} Vs time (number of humid days) for NPN and PNP transistors are shown.

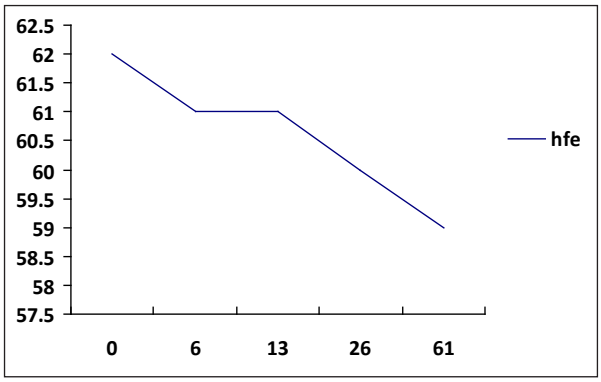
Graph 1

The graphical variation of h_{fe} vs time (number of humid days) for NPN Transistor.



Graph 2

The graphical variation of h_{fe} vs time (number of humid days) for PNP Transistor.



Conclusion

From the graph it is evident that forward current transfer ratio (h_{fe}) of transistors varies with time due to the absorption of moisture. This shows that the electrical performance of transistors is dependent on humidity. This

is due to the charge trapping by p-channel of the transistor that reduces the charge transport, i.e., the forward current transfer ratio.

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