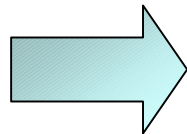




THE MECHANISM OF Ag_2S FORMATION



Sulphur



Product Engineering & Quality / October 2002



Ag₂S FORMATION

THE MECHANISM OF SILVER SULPHIDE GROWTH (1)

From the literature the following reactions are known.

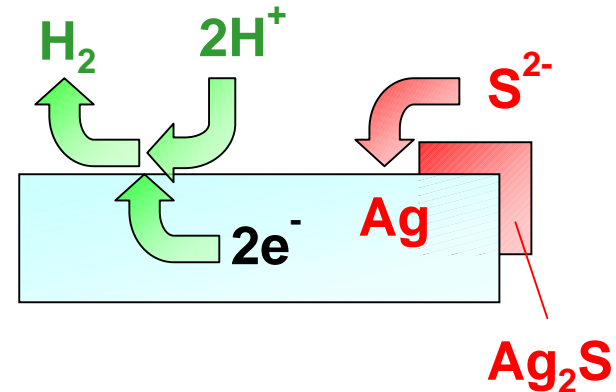
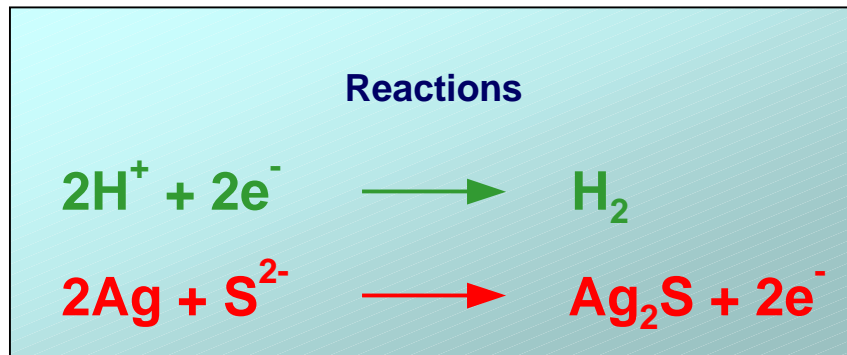
Reactions	Standard Electrical Potentials (25°C)
$2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2$	0 V
$\text{Ag}_2\text{S} + 2\text{e}^- \rightleftharpoons 2\text{Ag} + \text{S}^{2-}$	-0.71 V

When both reactions above are occurring, the lower electrical potential reaction proceed towards oxidation, while at the same time the reaction with the high standard electrical potential proceed towards deoxidation.

Ag₂S FORMATION

THE MECHANISM OF SILVER SULPHIDE GROWTH (2)

When a baked silver surface is exposed to sulphur ions, it is believed that the following reactions occur simultaneously, and silver sulphide is formed.

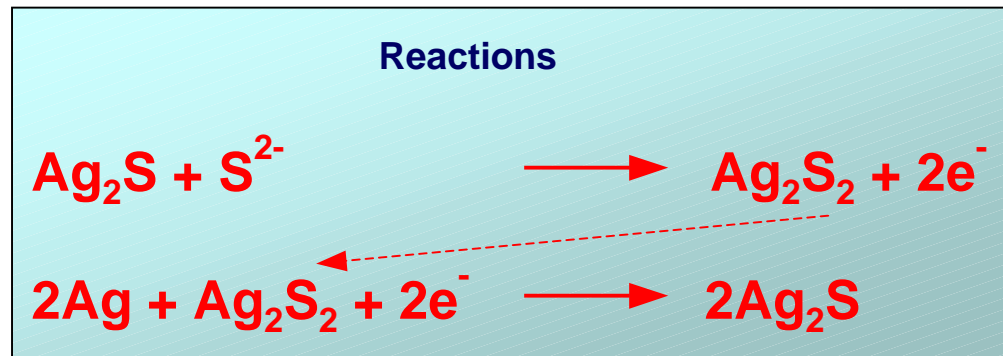


This phenomenon of metallic material deteriorating as a result of a chemical interaction with the surrounding environment is called corrosion.

Ag₂S FORMATION

THE MECHANISM OF SILVER SULPHIDE GROWTH (3)

The further growth of silver sulphide into needle-shaped crystals (monoclinic sulphur) is believed to be due to the following reactions.

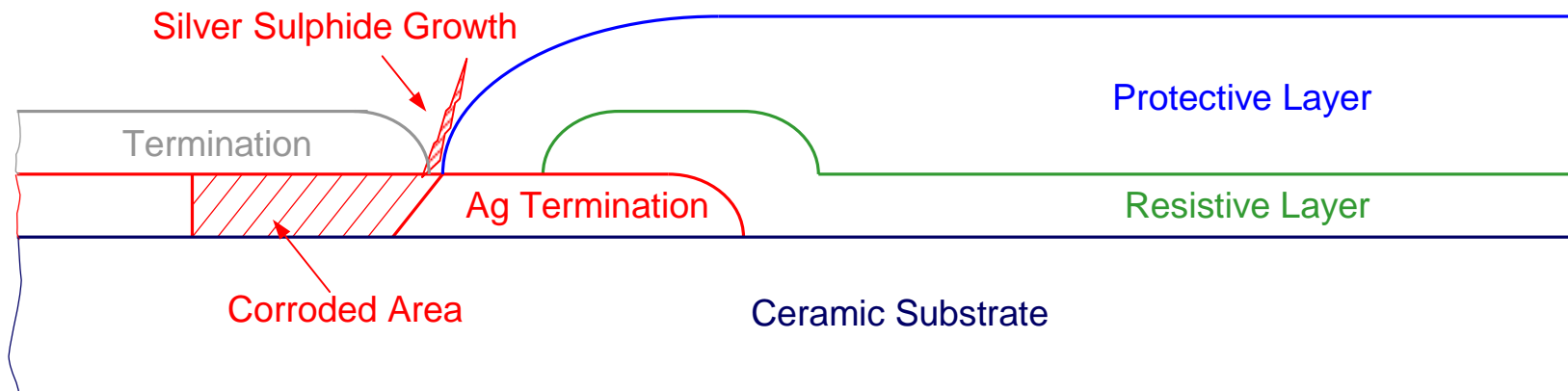
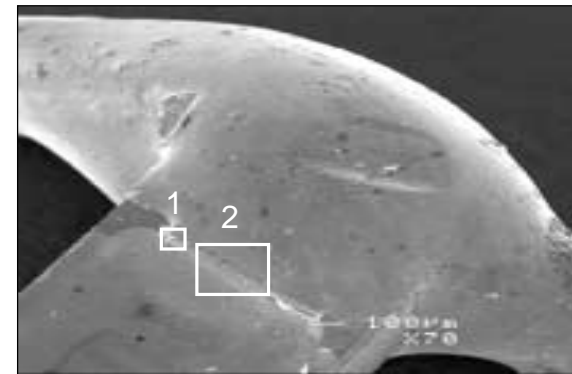
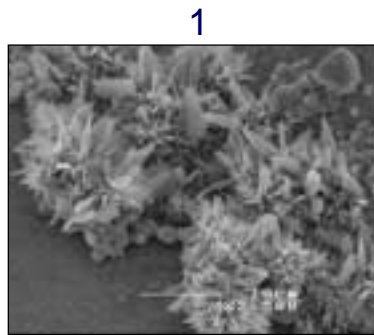


These reactions occur repeatedly, and the needle-shaped crystals of silver sulphide grow.

Ag₂S FORMATION

THE MECHANISM OF SILVER SULPHIDE GROWTH (4)

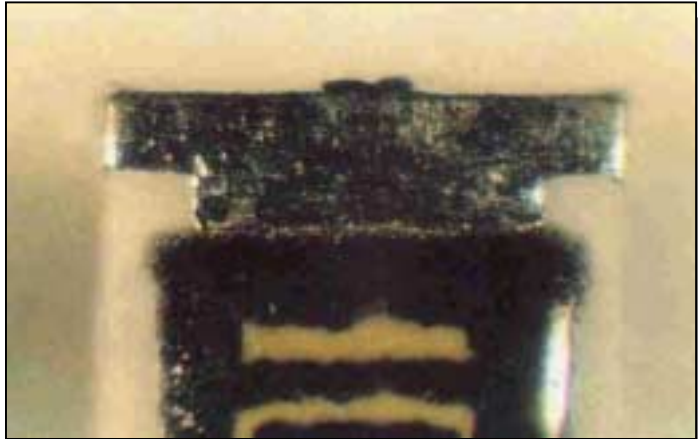
The sulphur and hydrogen ions get attached to the component surface along with moisture in the surrounding air and start the mechanism of silver sulphide growth.



Defective product affected with the growth of silver sulphide

Ag₂S FORMATION

GENERATION OF SILVER SULPHIDE GROWTH



Before sulphur testing (no KOA Resistor)



After sulphur testing (no KOA Resistor)

To see if products are susceptible to silver sulphide growth, tests are performed in a desiccator under fixed conditions.

Test conditions for “Sulphur Test”
(acc. to ASTM-B-809)

- H₂S concentration: (3 ± 1) ppm
- Temperature: (40 ± 2) °C
- Humidity: (91 – 93) % r.h.
- Rating: No power
- Duration: 1000 hours

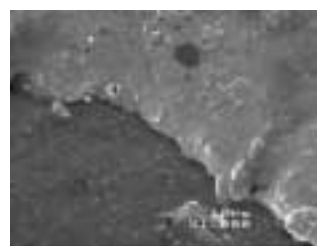
Ag₂S FORMATION

GENERATION OF SILVER SULPHIDE GROWTH – TEST METHOD

KOA Product



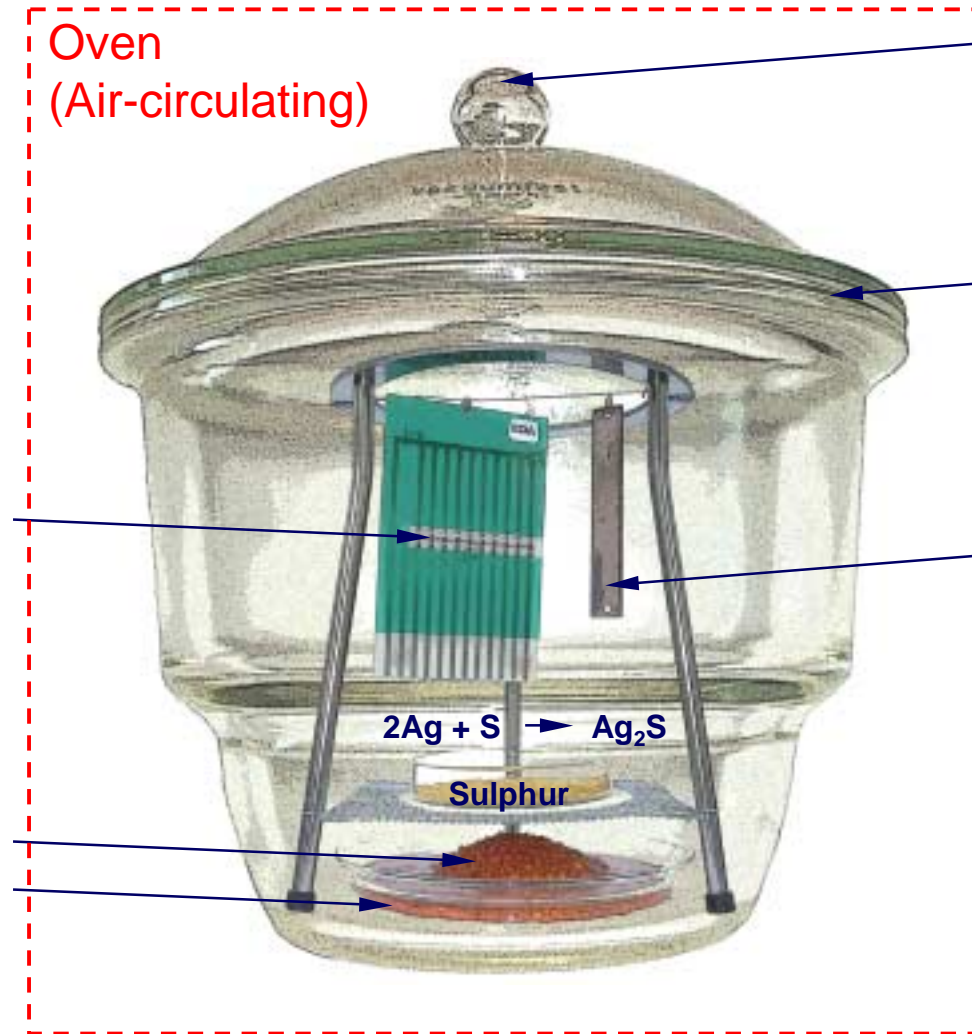
No Ag₂S Growth (x70)
after 1000 hours



No Ag₂S Growth (x1000)
after 1000 hours

KNO₃ (undissolved)
KNO₃ Solution
(to achieve a
constant humidity)

Oven
(Air-circulating)



Glass Desiccator

(40 ± 2)°C
(91 – 93) % r.h.
(inside the
glass desiccator)

Silver Coupon
(evidence of
silver growth)



Ag₂S Growth (x500)
after 1000 hours

Ag₂S FORMATION

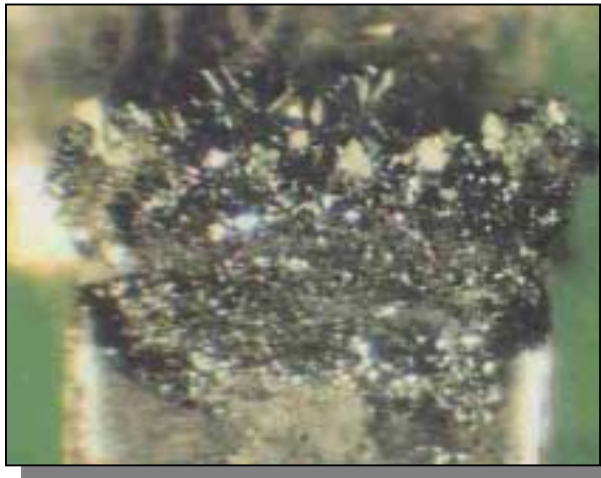
HOW TO AVOID SILVER SULPHIDE GROWTH?



KOA Standard product after H₂S testing

KOA uses Ag top terminations with additives and special production steps that the silver sulphide growth cannot occur.

The picture on the left side shows the standard Ag plating of KOA with special production steps.



Pure Ag termination after H₂S testing

The second picture on the left side shows a “normal” Ag plating without special production steps after 1000 hours “sulphur test”.

Remark: In both cases the Sn plating was stripped off, so that the top termination could react with the H₂S.

Ag₂S FORMATION

ENVIRONMENTS CONDUCTIVE TO SULPHURATION

The current state of our knowledge confirms that sulphuration occurs when chip resistors are exposed to environments such as the ones described below, in which sulphur ions are likely to occur in the surrounding atmosphere.

- Places where volcanic gases are emitted (including hot spring areas).
- In cases where sulphurous gas-emitting components have been mounted in the vicinity of the chip resistors.
- In cases where the base board on which the chip resistor are mounted has been moulded using vulcanized rubber.
- In places where there is a high concentration of vehicle exhaust fumes.

Thank you very much for your attention.



South Japan Alps & Ina Valley

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