APPLICATION**NOTE**

**Metal Films – TMA**

# Relaxation Measurements on Thin Metal Films by Means of Thermomechanical Analysis

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## Introduction

Thermomechanical analysis (TMA) is a technique for determining dimensional changes in solids, liquids or pasty materials as a function of temperature and/or time under a defined mechanical force (DIN 51005, ASTM E831, ASTM D696, ASTM D3386, ISO 11359 – Parts 1 to 3). As a software option, the TMA 402 *Hyperion*® offers not only the possibility to keep the force constant and measure the length change, but also to apply a strain and measure the corresponding force. This can, for example, be used in a stress relaxation test in which a sample is deformed by a specific amount at a defined temperature. During the test, the deformation is kept constant and the progression of the force is recorded. This force continuously decreases as a result of the material relaxation. The capability of maintaining the force at a constant value is called relaxation strength.

In this application note, the relaxation behavior of different metal films was studied using the displacement control software option. When metal films are permanently loaded at elevated temperatures, a decrease in force will be observed which is referred to as relaxation. The loss of strength increases with increasing temperature and load period. Thin metal films are, for example, used as contact systems in electromechanical components. Here, materials with high relaxation strength are important to maintain the contact for a longer period of time – sometimes also at higher temperatures.

## Measurement Conditions

The measurements were performed in 3-point bending (see figure 1). The samples were heated in a nitrogen atmosphere from room temperature to 200°C at a heating rate of 5 K/min. Then, the temperature was kept constant and the sample was bent by a predefined amount using the "displacement ramp" software option. The target strain was set to a suitable value to achieve an initial stress of ~1000 MPa, whereas the deformation was kept constant after initial loading in order to study the decaying force afterwards. While it takes a few seconds to apply the desired strain, the stress relaxation is observed for a period of 4 hours. Thus, the method applied and the instrument capabilities are well-suited to study effects on longer time scales like in this application example.

## Samples

Measurements were carried out on metal films of CuAg, CuBe and a Pd alloy. The samples had a thickness between 40 µm and 60 µm, a width of approx. 5 mm and were measured with a bending distance of 5 mm.

**1** Fixture set for 3-point bending made of fused silica, bending length: 5 mm.

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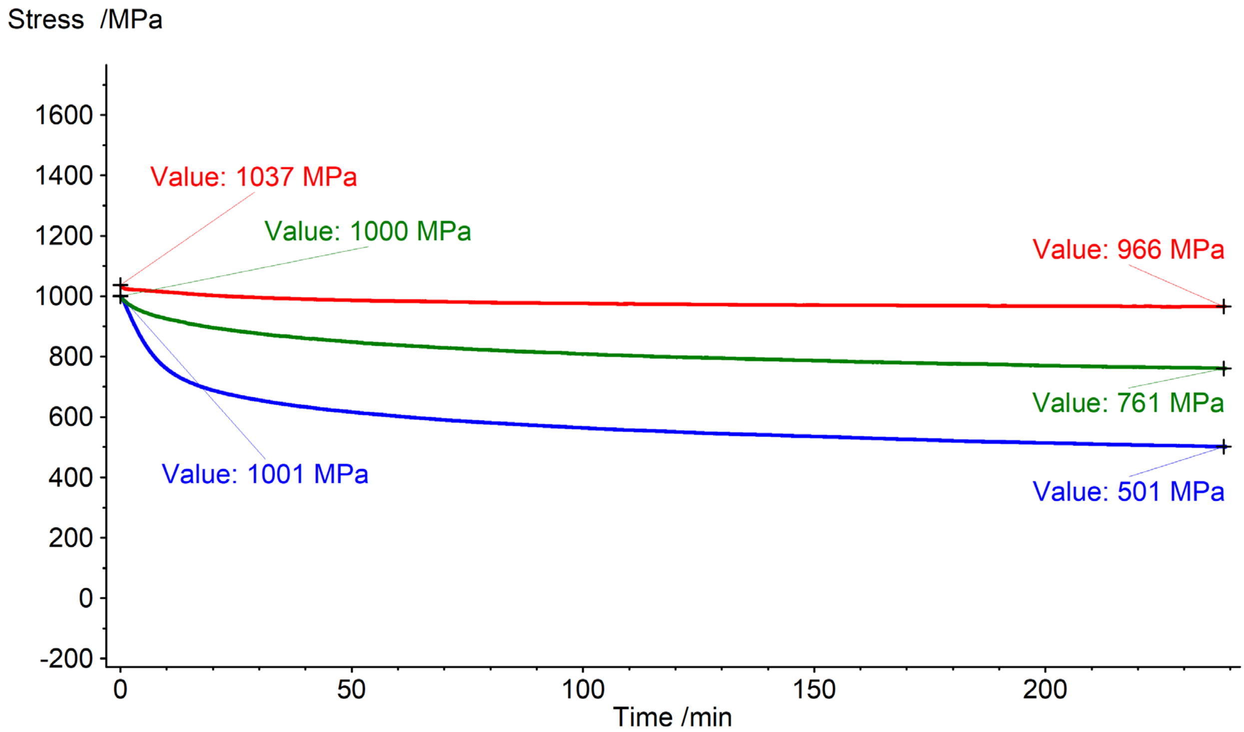
## Measurement Results

The results for the Pd film (red curve) and the two Cu films (CuAg: blue, CuBe: green curve) are depicted in figure 2. Due to the different stiffness of the three samples, different initial forces are required to generate the stress of 1000 MPa inside the sample. For all three samples, a decrease in stress was observed over a period of approx. 4 hours due to relaxation of the material. The lowest decrease of 71 MPa was measured for the Pd film and the highest of 500 MPa for the CuAg film. Thus, the Pd film shows the highest relaxation strength of these three samples.

## Conclusion

The TMA 402 *Hyperion®* with the software option for displacement control offers the possibility for relaxation measurements. As demonstrated, the relaxation behavior of different metal films can be studied and compared using the displacement control software option. This way, the influence of different tempering conditions or different compositions on the relaxation behavior of metal films can be examined.




2 Relaxation behavior of three different metal films at 200°C (red: Pd-alloy, green: CuBe, blue: CuAg)

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