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Thermal Expansion Coefficient of Expanded Austenite in Stainless Steel and CoCr Alloy

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It is recognized that the formation of expanded austenite resulting from low temperature (350-420 °C) incorporation of nitrogen induces internal stress by the compositional or chemical effect of nitrogen. However, thermal expansion can also be an important factor to take into account. Mismatch of thermal expansion coefficient is often the causal origin of stress build-up, defect creation and crack formation for thin film deposition at elevated temperatures. While the formation of expanded austenite by surface insertion of nitrogen and diffusion towards the bulk is conceptually different from applying coatings on substrates, similar restraints may be present concerning the cooling phase. Nevertheless, by measuring or monitoring the substrate reflections in parallel with those of the expanded phase in the surface layer using in-situ x-ray diffraction (XRD), it is possible to obtain detailed information on the thermal expansion coefficient of the expanded austenitic phase in austenitic stainless steel and CoCr alloys as function of processing temperature, duration and nitrogen supply. However, careful experimental design and data analysis have to be employed as secondary effects like vanishing substrate, phase transformations during the cooling phase or stress evolution may occur. One possible control experiment is repeated thermal cycling after ending the nitrogen insertion process. Another approach is to perform XRD experiments with a heating device on expanded austenite.
Summarizing the results of the thermal expansion coefficient for expanded austenite, no pronounced temperature dependence was observed in the accessible temperature range between 300 and 650 K, while absolute values have been obtained similar to those for austenitic stainless steel or CoCr, however additionally depending crucially on the processing conditions for nitrogen insertion, particularly the nitrogen content.

Keywords
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