Benard-Marangoni Instability as a Possible Modifier of Surface Alloy Composition

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The physics of thermophysical property determination is complex because the measurement requires the coming together of thermodynamics of achieving a thermal state, compositional and morphological property of a material specimen, responsive sensing elements, and robust interplay among them all. This is plainly evident in the wide variability seen in the thermophysical property literature. Metallic alloys, including single-element specimens, exhibit high variability, for example, in spectral emissivity and thermal diffusivity. We have demonstrated that some of the variability can be traced to the deviations of the near-surface elemental composition from one specimen to another of a given alloy [1] . Of interest is if the reasons are intrinsic. We have documented for a model system of Wood's alloy that it is possible to drive the elemental composition of a surface layer away from the composition of the bulk by thermal cycling of each specimen between melting and re-solidification. There exists a threshold melt temperature above which the near-surface composition is irreversibly modified. Such a near-surface composition anomaly can clearly affect the thermophysical property measurement. The method of time resolved spectroscopy of emissions from laser-produced plasma (LPP) plumes has been the key in this new development, in that both the elemental composition and thermal diffusivity can be measured simultaneously. Multiple application of LPP analysis leads to depth-resolved measurements. In this paper, we expand the application of the analysis into three dimensions in order to investigate mechanisms that are likely to drive such a near-surface composition anomaly. We focus attention on the Benard-Marangoni instability as a possible mechanism, because the alloy has a sequence of several phase transitions due to disparate melting points of constituent elements in the alloy, which gives rise to a complex temperature-dependent surface tension. We quench the 2-D patterns of counter flowing surface cells, and perform repetitive applications of 2-D surface analyses by LPP spectroscopy. The resulting 3-D profiles of elemental composition will be presented for a number of Wood's alloy specimens with different histories of thermal cycling.

[1] Y.W. Kim, *Int. J. Thermophys.* **26**, 1051 (2005).