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Comparative Effectiveness of Infrared Heat Sources for Mounting and Dismounting Electronic Modules

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Abstract—efficiency of short- and medium-wave infrared (IR) heat sources used to mount and dismount electronic modules is assessed. The analysis of the models of thermal fields shows that for KGM 30/300 halogen IR lamps, the heating nonuniformity for a printed circuit board is 45–55°C, and for the casings of electronic components, the temperature varies from 90 to 100°C. For an Elstein SHTS/4 ceramic IR heater, the heating nonuniformity for a printed circuit board is 8–13°C, the temperature of SMD component casings differs from temperature of the the printed circuit board: in BGA by 28–32°C, in QFP by 24–26°C, and in SMD by 5–20°C. The application of medium-wave ceramic infrared sources makes it possible to attain a higher heating uniformity in the working area and ensure an optimal temperature profile when mounting and dismounting surface-mounted electronic components.

Keywords: infrared radiation, heat sources, mounting, dismounting, electronic modules

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INTRODUCTION

When applying infrared sources, it is possible to perform local heating when mounting electronic modules, to decrease the heating time of a workpiece, and to reduce the risk of damage to electronic components. IR radiation heating has a number of advantages; however, they depend on the right choice of heat source and structure of the IR heating device. At present, two kinds of IR heating are widely used in technological processes: local focused and precise diffused. Depending on particular conditions, they use reflectors of various geometry that form a thermal field in the heating area [1].

The IR joint brazing procedure, which has a number of advantages, such as [2] a high rate and selective action of heating and the ability to control the thermal profile, calls for further development to improve the quality of mounting and dismounting of surface components in electronic densely packed modules. For the right choice of IR heat sources, one should analyze the thermal fields of heated bodies and estimate the influence of spacing between a heater and a printed circuit board on the heating uniformity and rate [3].

Today, local IR heating is the best method [4]. It uses a focused infrared radiation beam only in the brazing joints. In this case, printed circuit underboard heating to prevent its deformation is a mandatory procedure. The IR ceramic heaters maintain a stable temperature due to a high heating temperature and slow response that is of great importance for leadless brazing. The radiators which help to attain a high temperature in a minimum of time are used at the IR soldering stations.

A right choice of a heat source is the main factor which guarantees the quality of brazed joints of surface mounted components in the process of mounting and safety of a work-piece under repair when a damaged component is being dismounted. Applying IR sources it is possible to carry-out local heating, to reduce the time of heating a work-piece under repair, and to decrease the risk of damage to the electronic component.

The aim of the work is to assess the effectiveness of short- and medium-wave infrared heat sources used for mounting and dismounting the electronic modules, as well as to optimize temperature profiles of heating of the electronic surface–mounted components.

SIMULATION OF THERMAL FIELDS OF INFRARED SOURCES

The spectral radiation rate I depends on temperature T, wavelength λ, and spectral emissivity of the radiator [5]:

$$I_\lambda = \varepsilon_\lambda C_1 \lambda^{-5}(e^{C_2/\lambda T} - 1)^{-1}, \tag{1}$$

where C_1, C_2 are the Planck constants, 3.74 mW/kV m and 0.1439 m K; ε_λ is the reflection coefficient of the radiator.

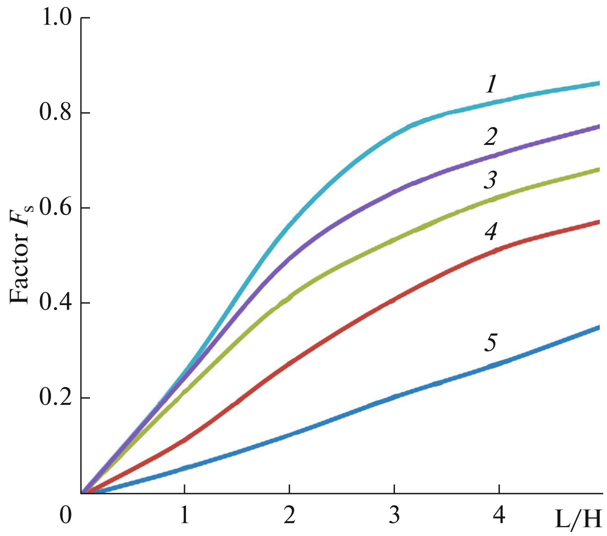

Fig. 1. Factor F_s versus source–surface spacings and dimensions of the heating areas: (*1*) between small source and square area (Fig. 2a); (*2*) between linear source and rectangular area (Fig. 2b); (*3–5*) between rectangular source and rectangular area with dimensions of $L \times L$, $L \times 2L$, and $L \times 5L$, respectively (Figs. 2c–2e).

The wavelength at which the blackbody radiation flux density reaches a maximum for this temperature is determined from Planck's law by fulfillment of the condition of the maximum [6]:

$$\frac{dE_\lambda}{d\lambda} = \frac{d}{d\lambda}\left[\frac{C_1}{\lambda^5\left(e^{C_2/\lambda T} - 1\right)}\right]_{T=\text{const}} = 0, \quad (2)$$

where E_λ is the blackbody radiation flux density at temperature T.

The solution to Eq. (2) gives the formula for the Wien displacement law:

$$\lambda_{\max} T = 2.898 \times 10^{-3} \text{ m K}, \quad (3)$$

where $\lambda_{\max}$ is the wavelength at which the maximum of the spectral radiation flux density of a blackbody with temperature T is attained.

Thus, a higher radiator temperature leads to a shorter wavelength and, as a result, to an increase in thermal emission. According to the Stefan–Boltzmann law, the heat radiated from the unit area is determined as in [5]:

$$Q = F_s \varepsilon \sigma S_h \left(T_h^4 - T_s^4\right), \quad (4)$$

where F_s is the angular coefficient (it is chosen from Fig. 1 depending on the ratio of the heater's dimensions and the brazing region (Fig. 2)), ε is the body emissivity; σ is the Stefan–Boltzmann constant, S_h is the heating area, T_h is the heater temperature, and T_s is the heated surface temperature.

The finite element method, which makes it possible to construct models of systems with complicated configurations and irregular structures, was used to simulate the IR processes. For IR heating, only the integral (i.e., total) wavelength radiation is considered. The heat-radiating surfaces are given as absolutely black, absolutely white, or completely gray; thus, according to the Lambert law, their radiation is assumed as diffuse, i.e., with luminosity independent of the direction of radiation. The initial conditions are

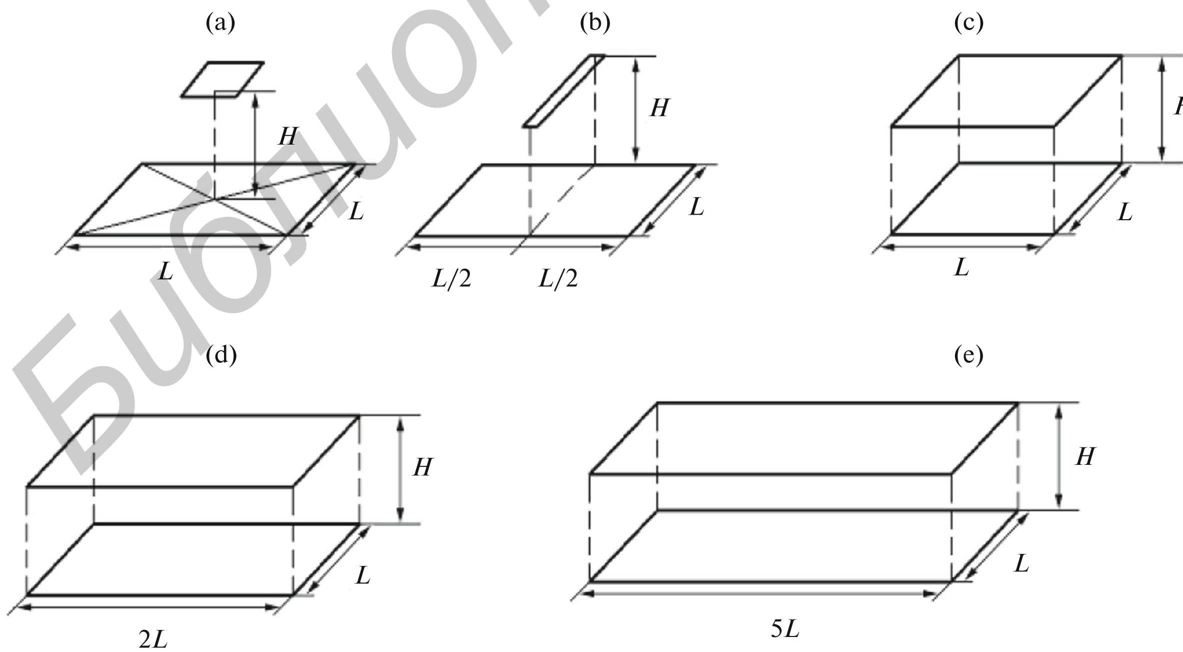

Fig. 2. Position of heaters with respect to heating areas.