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METHODOLOGY OF DETERMINATION THE YIELD OF VALID MICROSTRIP DEVICES DURING THEIR MANUFACTURING WITH OPERATIONAL TECHNOLOGICAL PROCESS CONTROL

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The presented technique makes it possible at the preparation stage to evaluate the economic feasibility of the production of microstrip devices. It can be taken into account all the technological stages of microstrip lines manufacturing.

Keywords: *microstrip device, technological process, yield of valid.*

Introduction

Due to the specific features of electromagnetic wave propagation in devices on microstrip lines (MSL), the output of such devices is sensitive to geometrical change of line sizes. However, the creation of microstrip lines with nominal sizes is impossible because of production fallibility. Therefore, on this stage of production preparation, the matter of economic feasibility of manufacturing the particular microstrip device should be taken in consideration. During the establishment a question of choice the optimal technological equipment remains in focus.

The methodology of determination the yield of valid microstrip devices manufactured with the particular technology

The method represented below is applicable, if only the deflection tolerance of MSL geometrical sizes, caused by different technology stages, adheres to normal or uniform distribution law [1]. This condition doesn't contradict the information represented in [2], where stated, that on practice the normal distribution law is used to define deflections in most technological processes in radio electronic devices production.

Algorythm of methodology can be described by the following steps:

1. Through the interval method [3] the tolerance deflection δ_i of geometrical parameter of microstrip devices is calculated. It influence on deflection of output function within δ_a interval. In this case $i = 1..m$, where *m* is a number of parameters.

2. The weights P_i' are introduced in order to get same tolerance deflections within low $-\delta_i'$ and upper $+\delta_i'$ limits.

3. To determine the boundary deflections dx_j, which are the result of different stages of a chosen technological process, when devices built on MSL have been produced (j=1,2…n, where *n* is a number of technological opereations, which influence on MSL geometry formation).

4. As the process of MSL topology formation comprises more than a dozen technological opereations [2], the Liapunov's theory can be further used [1], [4]. The essence of this theory is reflected in the following statement, that a distribution law of a sum of independent random variables dx_j is close to normal distribution, when *n* increses unlimitedly and two conditions are satisfied [1]:

– all magnitudes have the finite evaluated cases $M(dx_j)$ and variance $D[dx_j]$;

– each of magnitudes doesn't contrast sharply with the others.

The quantity *n* can be less than 10, if all magnitudes are determined by normal or uniform distribution law [1].

The variability, that $\overline{dx}$ falls within the range $[-\delta_i';+\delta_i']$, is calculated by the formula:

$$P1 = P\left\{-\delta_i' < \overline{dx} < +\delta_i'\right\} \approx \frac{1}{\sqrt{2\pi D\left[\overline{dx}\right]}} \cdot \int_{-\delta_i'}^{+\delta_i'} e^{-\frac{(dx - M(d\bar{x}))^2}{2D\left[\overline{dx}\right]}} ddx, \quad (1)$$

where $\overline{dx} = \frac{dx_1 + dx_2 + ... + dx_n}{n}$.

5. If the operation of the final control is considered with variability β of identifing and remeding the defects from a batch, than the valid yield will be estimated as:

$$P2 = \frac{P1}{1 - (1 - P1) \cdot \beta}. \quad (2)$$

In general an inter-operational control of technological process of MSL production can be held the following way. The valid yield is determined every time after particular number of operations $n' < n$, than monitoring, when $P1_{n'}$ and $P2_{n'}$ are calculated by (1) and (2) formulas, respectively. The result value of valid output is:

$$P3 = \prod_{n'=1}^{n} P2_{n'}. \quad (3)$$

The existence of monitoring has an impact on productive expenses [6]:

$$C = \sum\left(\alpha \cdot k_j + c_j\right) + \sum\left(\alpha \cdot k_{j+1} + c_{j+1}\right) \cdot \left(1 - \beta_j\right) + ..., \quad (4)$$

where $\alpha = 1$ – an existence of checkpoint;

$\alpha = 0$ – an absence of checkpoint;

k – the costs of providing the monitoring;

c_j – the cost of j control operation.

The topology formation of the MSL devices consists of such phases [4]:

1) Photo mask creation:

- desing and convert information in a digital form (if necessary);
- setting of optical image generators;
- photo processing (development, etching, hardening etc.)

2) Image formation:
- resist application;
- drying;
- exposure;
- development;
- finish heat treatment;
- etching;
- resist removal.

Example of usage the method

For example, we produce a lowpass filter implemented by a single pin resonator Pic.1. For this purpose, we use a definite technology, where the expected value of a deflection sum estimated as $M(\bar{x})=5$ and variance $D[\bar{x}]=1440$. Thus, using the formula 1 the variability of geometrical parameter deflection in produced lowpass filter for a range in between [-9,73; 6,39] μm will be

$$P\{-9{,}73 < x < 6{,}39\} \approx \frac{1}{\sqrt{2\pi \cdot 1440}} \cdot \int_{-9{,}73}^{+6{,}39} e^{-\left(\frac{(x-5))^2}{2\cdot 1440}\right)}.$$

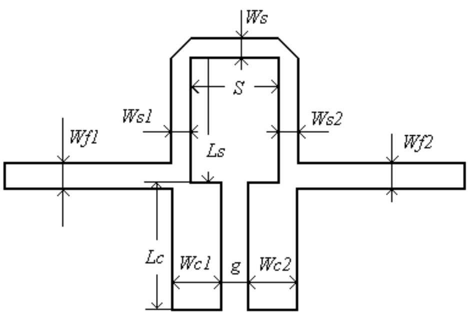
With a standard distribution function this calculation will take a view [1]:

$$P\{-9{,}73 < \bar{x} < 6{,}39\} = 0{,}166$$

For electronics industry this indicator is low, as a valid yield between 0,5 and 0,7 is considered to be low [2].

If a technological process wil be represented with checkpoints, so that the defects are identified and remedied from a batch with the variability $\beta = 0{,}96$, the valid yield according to formula (2) will increase to

$$P2 = \frac{0{,}166}{1-(1-0{,}166)\cdot 0{,}96} = 0{,}833 \cdot$$



Pic. 1. A lowpass filter implemented by a single pin resonator

The cost of technological process, which conditionally amounts to 1000 UAH and the checkpoint costs are conditionally 200 UAH, therefore will raise to (formula 4)

$$C = (200+1000)+(1000+200)\cdot(1-0{,}96) = 1248 \text{ (UAH.)}.$$

If the control operations are used, these data corroborated, that production of lowpass filter with geometrical parameter deflection on [-9,73; 6,39] μm and expected value of the sum deflection distribuition $M(\bar{x})=5$, resulted from the features of technological process, and variance at $D[\bar{x}]=1440$, is economically feasible, as a suitable relese rate in range of 0,7 to 0,9 is average.

Conclusion

The analyzed methodology enables to estimate the economic feasibilty of production the MSL devices, if the deflections of technological processes are distributed by normal or uniform law. Furthermore, it gives the opportunity to take into account a wide range of technological processes.

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