POLYMER CHAIN EFFECTS IN NANOIMPRINTING

M.V. Chukalina, V.V. Sirotkin, A.A. Svintsov, S.I. Zaitsev
Institute of Microelectronics Technology, RAS, Chernogolovka, Moscow district 142432, Russia
E-mail: zaitsev@ipmt-hpm.ac.ru

Polymer matter used for NanoImprint Lithography consists usually from long polymer chain and comprises a melt. It is known that polymer chains in the melt exist in forms of Gaussian coils. For PMMA of 950 K molecular weight the size of this coils is about 100 nm (20 nm for PMMA of 25 K). The size is comparable with or exceeds structure features tested and discussed now in NIL. Some long chain effects are considered in the report.

Such equilibrium effect as additional pressure of polymer melts restricted in volume is estimated and compared with typical surface tension of polymer-substrate interface.

Nonequilibrium phenomena like viscose flow and deformation of polymer at this scale should also be revised as the viscosity becomes nonlocal and usual hydrodynamic equations are not valid at such distances. Quantitative consideration and a simple qualitative model developed result in the conclusion that there is a limiting polymer thickness achievable at the imprinting and residual polymer layer can not be made thinner than size of the coil.

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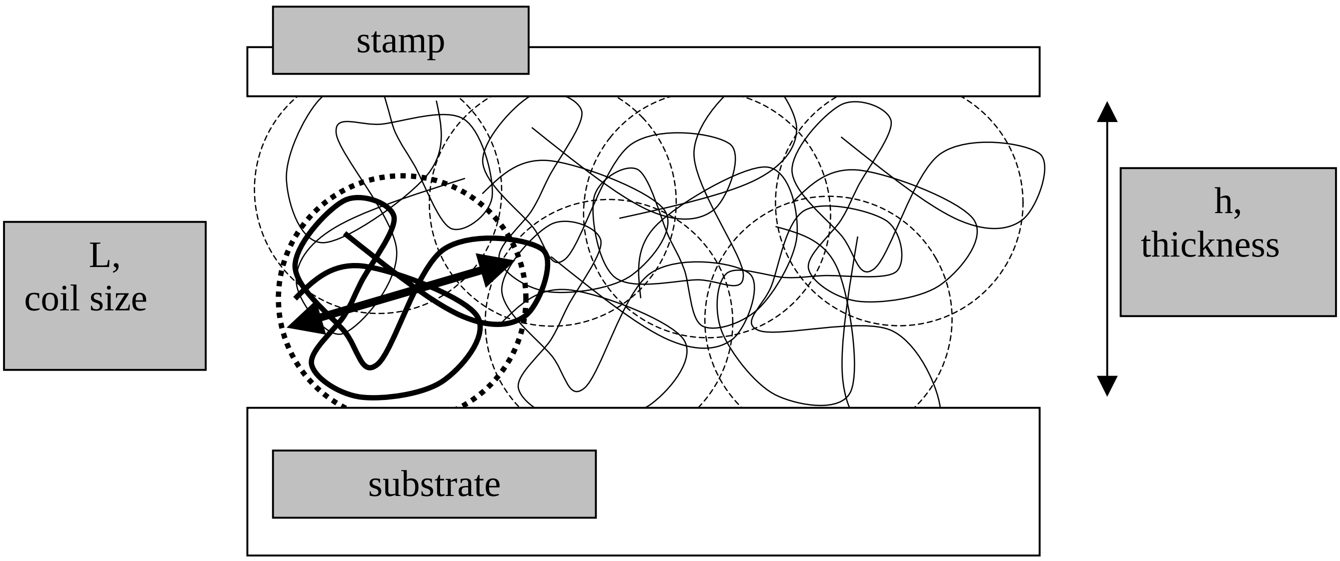

Fig.1 Polymer matter consists of long polymer chains existing in the matter as “coils”. Features of a stamp at nanoimprinting is larger than size of coils, this result in some effects.

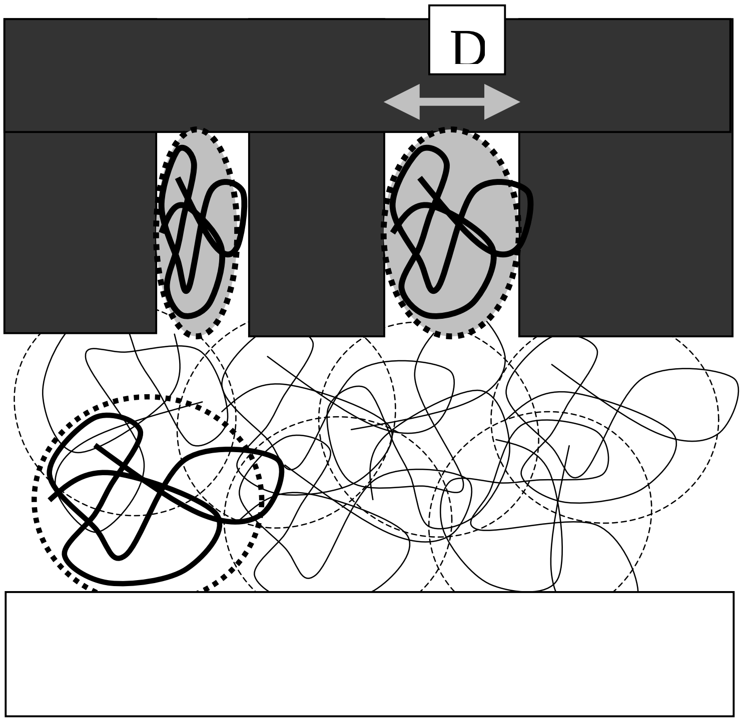

Fig.2 During imprinting some coils are forced to be imprinted in stamp cavities of size D. For D less than coil size L it is possible if pressure exceeds some estimated value.

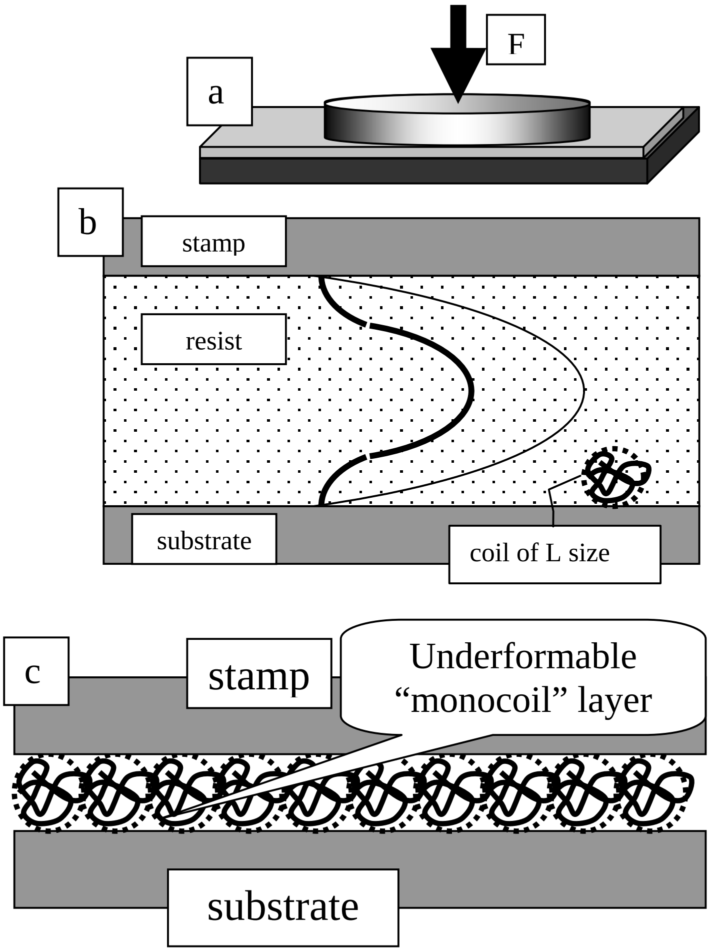

Fig.3a A disk (flat stamp) of radius R is moved with velocity u through liquid (of viscosity $\eta(z)$) when h is a distance to another disk is known as Reinolds problem.
Fig.3b Thin curve represents parabolic distribution of velocity in classical Reinolds problem. Consideration of chain effect when any chain contacting to surface becomes immobile result to velocity profile shown as thick curve

Fig.3c At some thickness close to size L (=100-20nm) the resist layer becomes “undeformable”.