Student Paper

A Low Cost Micro-Hot-Plate for Disposable Aerosol Generation Applications

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In this work we describe a fabrication process for a low cost micro-hot-plate (MHP) for use as a disposable aerosol generator. The manufacturing uses thin film deposition, electroless metal plating and selective wet etching. We use shadow masking or simple contact printing for pattern definition. The micro-heater (MH) and MHP system's thermal and electrical behaviors are reported. This microstructure consists of a free standing amorphous silicon membrane with a thin film MH (Cr/Ni layer) on top. The MH is fabricated by e-beam evaporation seed layer and solution based nickel plating method. The membrane temperature can easily reach the boiling point of solvent. Wet etched formed reservoirs are used for aerosol source. The reservoirs can be placed along side or underneath the hot plate. The whole process is performed on a microscope cover glass. This combined with the use of a plating bath and wet etch, renders the device remarkably low cost as compared to other silicon technology based heaters.

Over the past decade, great interest has been shown in low cost, fast response, low-power micro-heaters [1] for a variety of applications. MH and MHP may be integrated in chemical sensors and gas sensors [2], humidity sensors, and micro fluidic pumps to create exceptional control in aerosol creation, monitoring and dispersal. They can also be widely used in medical care that drugs are aerosolized and delivery through inhaled or nasal cannulas [3]. Moreover, they can be powered by high charge-capacity, light weight, flexible battery sources [4,5].

Three types of MH have been developed, which differ by the position of the storage reservoir of the liquid to be evaporated: (i) side reservoir, (ii) bottom reservoir and (iii) top reservoir. Process flow diagrams for each approach are shown in Fig.1, Fig.2 and Fig.3 respectively.

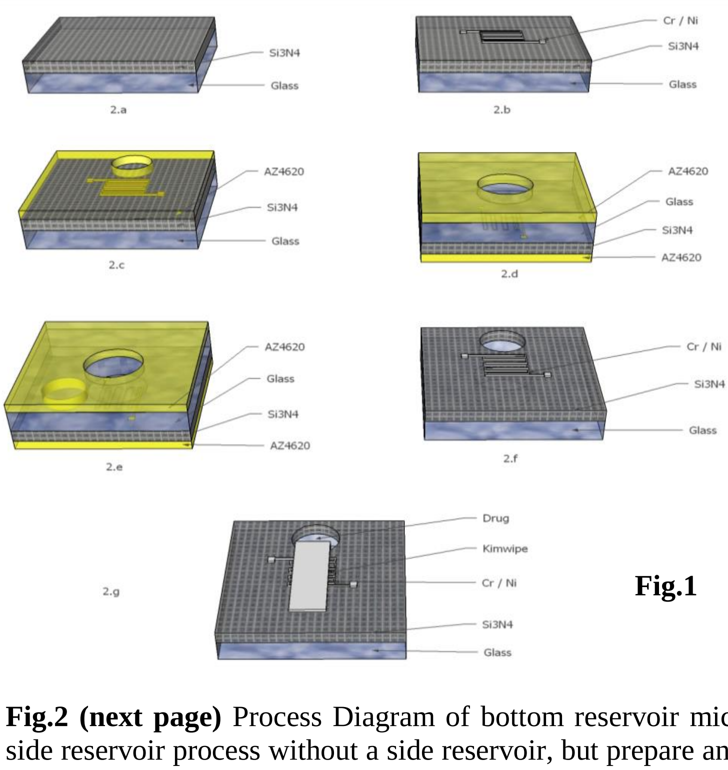

Fig.1

Fig.1 Process flow diagram for side reservoir MHs. **a)** Micro-cover-glass deposit silicon nitride or amorphous silicon layers by PECVD. **b)** Adhesion Cr layer and seed layer of Ni deposed by E-Beam Thermal Evaporator followed by thick Ni bath plating. **c)** Spin photo-resist layer followed by photo-lithography to define the storage reservoir area. **d)** Flip the sample over and spin photo-resist layer followed by photo-lithography to define the wet etch free standing membrane area. **e)** HF/HCl wet etch both sides. **f)** Remove photo-resist and flip over the sample. **g)** Fill drug solution into the reservoir and use a wick on top of MH, connecting into reservoir.

Fig.2 (next page) Process Diagram of bottom reservoir micro-heaters. **a)** to **f)** steps are the same with side reservoir process without a side reservoir, but prepare another peace by **g)** Take samples from step a) and flip over, spin photo-resist layer followed by photo-lithography to define the wet etch area for reservoir. **h)** HF/HCl wet etch the glass and form the bottom reservoir. **i)** Remove photo-resist, this is the bottom part of the micro-heater. **j)** Seal the top and bottom part with using acrylic glue, use a wick to connect to the reservoir and cover over the heater pattern.

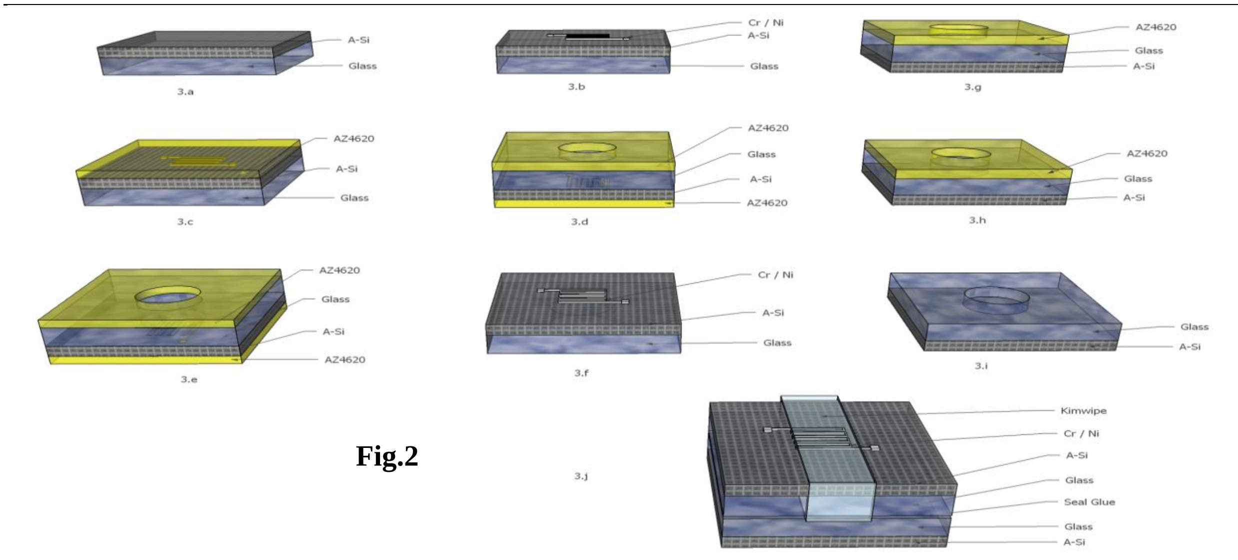

Fig.2

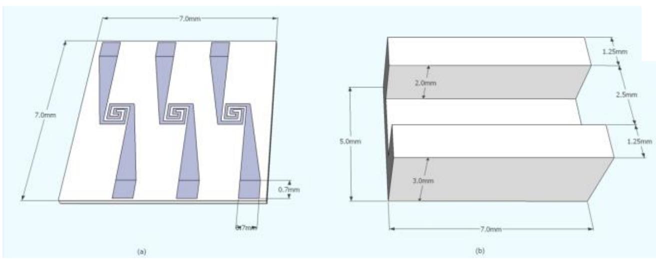

Fig.3

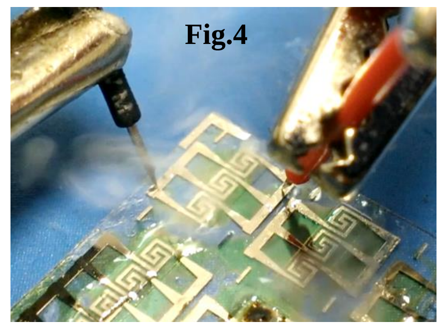

Fig.4

Fig.3 Process Diagram of a top reservoir micro-heater. **a)** Normal micro heaters without reservoir. **b)** A PVC mold made top reservoir.

Fig.4 Pictures of top and bottom reservoir type micro-heaters (heater pattern piece only). The membrane film is silicon nitride by PECVD. A huge amount of aerosol is generated.

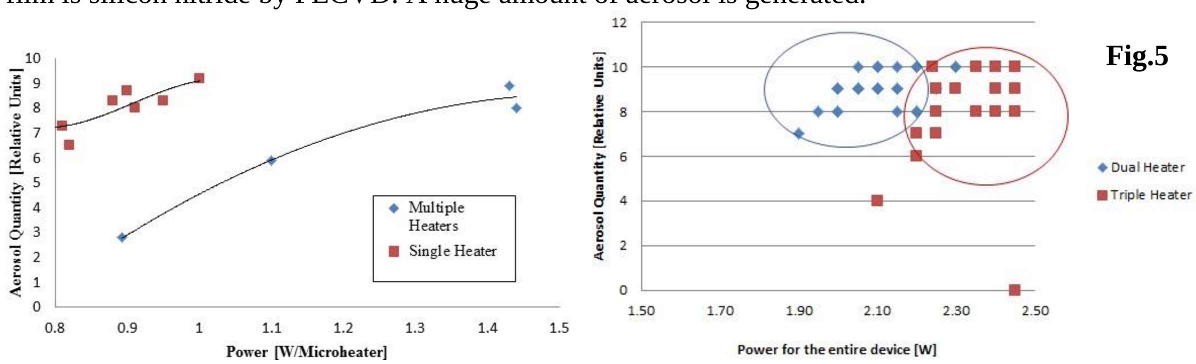

Fig.5

Fig.5 Aerosol quantity relative to power required for its generation for single, dual and triple heater (the numeric rating of aerosol quality is: 10 – abundant, 8 - very good, 6 – good, 4 – fair, 2 – poor, 0 – none).

References

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