CLAIMS

What is claimed is:

1. A method of fabricating a plurality of carbon nanotube-bundle probes on a substrate, said method comprising:

providing a substrate having a top surface and a bottom surface;

forming an array of electrically conductive pads on said top surface;

applying a catalyst for promoting growth of carbon nanotubes on each of said array of electrically conductive pads; and

heating said substrate in a carbon-rich environment thereby growing nanotubes extending upwardly from each of said array of electrically conductive pads

2. A method according to claim 1, wherein said array of electrically conductive pads are formed to mirror an array of pads on an integrated circuit that is to be tested.

3. A method according to claim 1, wherein said carbon nanotubes are grown above said top surface of said substrate thereby forming a plurality of carbon nanotube-bundle probes extending upwardly above said top surface of said substrate.

4. A method according to claim 1, further comprising capping each of said plurality of carbon nanotube-bundle probes with an electrically conductive material.

5. A method according to claim 1, wherein said conductive pads include first and second concentric rings, said first concentric ring being a ground ring and said second concentric ring being a signal pad.

6. A method of fabricating a plurality of carbon nanotube-bundle probes on a substrate, said method comprising:

providing a substrate having a top surface, a bottom surface, and an array of micro-holes drilled through and connecting said top and bottom surfaces;

providing a metal foil having top and bottom surfaces;

applying a catalyst for promoting growth of carbon nanotubes to said top surface of

said metal foil,

joining said top surface of said metal foil to said bottom surface of said substrate;

heating said metal foil and said substrate in a carbon-rich environment thereby causing each of said array of micro-holes in said substrate to expand thereby forming an array of expanded micro-holes in said substrate;

growing nanotubes extending upwardly from said top surface of said metal foil through each of said array of expanded micro-holes in said substrate to form a plurality of carbon nanotube-bundle probes;

cooling said metal foil and said substrate thereby causing each of said array of expanded micro-holes in said substrate to contract thereby forming an array of contracted micro-holes in said substrate; and

removing said metal foil from said bottom surface of said substrate.

7. A method according to claim 6, wherein said metal foil being configured for joining with said bottom surface of said substrate.

8. A method according to claim 6, wherein said carbon nanotubes are grown above said top surface of said substrate thereby forming a plurality of carbon nanotube-bundle probes extending upwardly above said top surface of said substrate.

9. A method according to claim 8, wherein each of said plurality of carbon nanotube-bundle probes substantially fills a respective one of said array of expanded micro-holes.

10. A method according to claim 6, wherein each one of said array of contracted micro-holes provides a shrink fit around a respective one of said plurality of carbon nanotube-bundle probes contained therein so as to substantially secure said respective one of said plurality of carbon nanotube-bundle probes contained therein to said substrate.

11. A method according to claim 6, wherein said array of micro-holes are drilled at an angle not perpendicular to said top surface of said substrate thereby causing said nanotubes to grow at an angle not perpendicular to said top surface of said substrate.

12. A method according to claim 6, wherein each one of said array of micro-holes is tapered.

13. A method according to claim 12, further comprising providing a solder or epoxy backfill to said array of micro-holes.

14. A method according to claim 6, further comprising plating or solder bumping each of said plurality of carbon nanotube-bundle probes adjacent said bottom surface of said substrate.

15. A method of fabricating a plurality of carbon nanotube-bundle probes extending from opposing surfaces of a substrate, said method comprising:

providing a substrate having a top surface, a bottom surface, and an array of micro-holes drilled through and connecting said top and bottom surfaces;

providing a first metal foil having top and bottom surfaces and an array of holes drilled through and connecting said top and bottom surfaces;

providing a second metal foil having top and bottom surfaces;

applying a catalyst for promoting growth of carbon nanotubes;

joining said top surface of said first metal foil to said bottom surface of said substrate;

joining said top surface of said second metal foil to said bottom surface of said first metal foil;

heating said second metal foil and said substrate in a carbon-rich environment thereby causing each of said array of micro-holes in said substrate to expand thereby forming an array of expanded micro-holes in said substrate;

growing nanotubes extending upwardly from said top surface of said second metal foil through each of said array of holes in said first metal foil and said array of expanded micro-holes in said substrate and above said top surface of said substrate thereby forming a plurality of carbon nanotube-bundle probes extending upwardly above said top surface of said substrate, each of said plurality of carbon nanotube-bundle probes substantially filling a respective one of said array of expanded micro-holes; and

cooling said second metal foil and said substrate.

16. A method according to claim 15, wherein said array of holes are arranged to align with said array of micro-holes in said substrate

17. A method according to claim 15, wherein said metal foil is configured for joining with said bottom surface of said first metal foil

18. A method according to claim 15, wherein said array of holes in said first metal foil is substantially aligned with said array of micro-holes in said substrate.

19. A method according to claim 15, wherein cooling causes each of said array of expanded micro-holes in said substrate to contract thereby forming an array of contracted micro-holes in said substrate, each one of said array of contracted micro-holes providing a shrink fit around a respective one of said plurality of carbon nanotube-bundle probes contained therein so as to substantially secure said respective one of said plurality of carbon nanotube-bundle probes contained therein to said substrate.

20. A method according to claim 15, further comprising removing said first and second metal foils from said bottom surface of said substrate.

Claims

What is claimed is:

1. A method of fabricating a plurality of carbon nano-tube-bundle probes (202) on a substrate (204), said method comprising:

providing a substrate (204) having a top surface (214), a bottom surface (210) and an array of microholes (216) drilled through and connecting said top and bottom surfaces (210);

providing a metal foil (206) having top (220) and bottom surfaces (222);
applying a catalyst (208) for promoting growth of carbon nanotubes to said top surface (220) of said metal foil (206);

joining said top surface (220) of said metal foil (206) to said bottom surface (210) of said substrate (204); heating said metal foil (206) and said substrate (204) in a carbon-rich environment thereby causing each of said array of micro-holes (216) in said substrate (204) to expand thereby forming an array of expanded micro-holes (216) in said substrate (204);

growing nanotubes extending upwardly from said top surface (220) of said metal foil (206) through each of said array of expanded micro-holes (216) in said substrate (204) to form a plurality of carbon nanotube-bundle probes (202); cooling said metal foil (206) and said substrate (204) thereby causing each of said array of expanded micro-holes (216) in said substrate (204) to contract thereby forming an array of contracted micro-holes (216) in said substrate;
and

removing said metal foil (206) from said bottom surface (210) of said substrate (204).

2. The method according to claim 1, wherein said metal foil (206) being configured for joining with said bottom surface (210) of said substrate (204).

3. The method according to claim 1, wherein said carbon nanotubes are grown above said top surface (214) of said substrate (204) thereby forming a plurality of carbon nanotube-bundle probes (202) extending upwardly above said top surface (214) of said substrate (204), and wherein preferably each of said plurality of carbon nanotube-bundle probes (202) substantially fills a respective one of said array of expanded micro-holes (216).

4. The method according to claim 1, wherein each one of said array of contracted micro-holes (216) provides a shrink fit around a respective one of said plurality of carbon nanotube-bundle probes (202) contained therein so as to substantially secure said respective one of said plurality of carbon nanotube-bundle probes (202) contained therein to said substrate (204).

5. The method according to claim 1, wherein said array of micro-holes (216) are drilled at an angle not perpendicular to said top surface (214) of said substrate (204) thereby

causing said nanotubes to grow at an angle not perpendicular to said top surface (214) of said substrate (204).

6. The method according to claim 1, wherein each one of said array of micro-holes (216) is tapered, and preferably further comprising providing a solder or epoxy backfill to said array of micro-holes (216).

7. The method according to claim 1, further comprising plating or solder bumping each of said plurality of carbon nanotube-bundle probes (202) adjacent said bottom surface (210) of said substrate (204).

8. A method of fabricating a plurality of carbon nano-tube-bundle probes (402) extending from opposing surfaces of a substrate (404), said method comprising:

providing a substrate (404) having a top surface (406), a bottom surface (408), and an array of micro-holes (410) drilled through and connecting said top (406) and bottom surfaces (408);

providing a first metal foil (414) having top (416) and bottom surfaces (418) and an array of holes (420) drilled through and connecting said top (416) and bottom surfaces (418);

providing a second metal foil (422) having top (424) and bottom surfaces (426);

applying a catalyst (430) for promoting growth of carbon nanotubes;

joining said top surface (416) of said first metal foil (414) to said bottom surface (408) of said substrate (404);

joining said top surface (424) of said second metal foil (422) to said bottom surface (418) of said first metal foil (414);

heating said second metal foil (422) and said substrate (404) in a carbon-rich environment thereby causing each of said array of micro-holes (410) in said substrate (404) to expand thereby forming an array of expanded micro-holes (410) in said substrate (404);

growing nanotubes extending upwardly from said top surface (424) of said second metal foil (422) through each of said array of holes (420) in said first metal foil (414) and said array of expanded micro-holes (410) in said substrate (404) and above said top surface (406) of said substrate (404) thereby forming a plurality of carbon nanotube-bundle probes (402) extending upwardly above said top surface (406) of said substrate (404), each of said plurality of carbon nanotube-bundle probes (402) substantially filling a respective one of said array of expanded micro-holes (410); and

cooling said second metal foil (422) and said substrate (404), removing said first (414) and second metal foils (422) from said bottom surface (408) of said substrate (404).

9. The method according to claim 8, wherein said metal foil (422) is configured for joining with said bottom surface (418) of said first metal foil (414).

10. The method according to claim 8, wherein said array of holes (420) are arranged to align with said array of micro-holes (410) in said substrate (404), or wherein said array of holes (420) in said first metal foil (414) is substantially aligned with said array of micro-holes (410) in said substrate (404).

11. The method according to claim 8, wherein cooling causes each of said array of expanded micro-holes (410) in said substrate (404) to contract thereby forming an array of contracted micro-holes (410) in said substrate (404), each one of said array of contracted micro-holes (410) providing a shrink fit around a respective one of said plurality of carbon nanotube-bundle probes (402) contained therein so as to substantially secure said respective one of said plurality of carbon nanotube-bundle probes (402) contained therein to said substrate (404).