To form a vapor bubble in the bubble forming liquid, the surface of the protective layers in contact with the bubble forming liquid must be heated to the superheat limit of the liquid (~300°C for water). This requires that the entire thickness of the protective layers be heated to (or in some cases above) the liquid superheat limit. Heating this additional volume decreases the efficiency of the device and significantly increases the level of residual heat present after firing. If this additional heat cannot be removed between successive firings of the nozzle, the ink in the nozzles will boil continuously, causing the nozzles to cease ejecting droplets in the intended manner.

The primary cooling mechanism of printheads on the market is currently thermal conduction, with existing printheads implementing a large heat sink to dissipate heat absorbed from the printhead chip. The ability of this heatsink to cool the liquid in the nozzles is limited by the thermal resistance between the nozzles and the heatsink and by the heat flux generated by the firing nozzles. As the extra energy required to heat the protective layers of a coated heater contributes to an increased heat flux, more severe constraints are imposed on the density of the nozzles on the printhead and the nozzle firing rate. This in turn has an impact on the print resolution, the printhead size, the print speed and the manufacturing costs.

SUMMARY OF THE INVENTION

Accordingly the present invention provides an inkjet printhead for ejecting drops of liquid on to a media substrate, the inkjet printhead comprising:

a chamber for holding liquid;

a nozzle in fluid communication with the chamber;

a heater positioned in the chamber for thermal contact with the liquid such that resistive heating of the heater generates a vapour bubble that ejects a drop of the liquid through the nozzle; wherein,

the heater is formed from a TiAlX alloy where Ti contributes more than 40% by weight, Al contributes more than 40% by weight and X contributes less than 5% by weight and comprises zero or more of Ag, Cr, Mo, Nb, Si, and Ta ~~and W~~. Furthermore, the heater has a microstructure with a grain size less than 100 nanometres, and X comprises W.

Titanium aluminium (TiAl) alloys exhibit superior strength, low creep and light weight; properties which have seen these alloys widely used in the aeronautical and automotive industries. However, the Applicant's work has revealed that TiAl is also well suited to use

as a heater material in inkjet printheads. The alloy can provide surface oxide that is a uniform, thin and dense coating of predominantly Al_2O_3, which has very low oxygen diffusivity. Accordingly, the native (i.e. naturally forming) oxide layer passivates the heater to guard against oxidative failure while remaining thin enough not thermally insulate the heater from the ink. This preserves the low energy ejection of drops that is necessary for large (pagewidth), high density nozzle arrays, without compromising the operational life of the heater.

Further improvement in oxidation resistance can be obtained with additive element X, which has been found to enhance the diffusivity of aluminium, thereby encouraging the formation of Al_2O_3 whilst suppressing the formation of TiO_2. TiO_2 has much higher oxygen diffusivity than Al_2O_3, so suppressing its formation relative to Al_2O_3 provides improved oxidation resistance.

Optionally ~~X is W~~, the~~or X includes~~ W ~~which~~ contributes between 1.7% and 4.5% by weight.

~~Optionally Ti contributes more than 48% by weight, Al contributes more than 48% by weight and X is 0% by weight.~~

Optionally the TiAl component of the heater has a gamma phase structure.

Optionally the heater has a microstructure with a grain size less than 100 nanometres.

Optionally the TiAlX alloy forms an Al_2O_3 surface oxide which directly contacts the liquid during use.

Optionally the TiAlX alloy is deposited as a layer less than 2 microns thick. Preferably the layer is less than 0.5 microns thick.

Optionally the heater further comprises a protective coating, the protective coating having a total thickness less than 0.5 microns. Optionally the protective coating is a single layer of material. Optionally the protective coating is at least partially formed from a silicon oxide, nitride or carbide.

In an embodiment~~a second aspect~~ the present invention provides a MEMS device for generating a bubble, the MEMS device comprising:

a chamber for holding liquid;

a heater positioned in the chamber for thermal contact with the liquid; wherein,

the heater has a microstructure with a grain size less than 100 nanometres and configured to received an actuation signal from associated drive circuitry such that upon actuation the heater heats some of the liquid to a temperature above its boiling point in order to generate a vapor bubble that causes a pressure pulse through the liquid.

A grain size less than 100nm (a "nanocrystalline" microstructure) is beneficial in that it provides good material strength yet has a high density of grain boundaries. Compared to a material with much larger crystals and a lower density of grain boundaries, the nanocrystalline structure provides higher diffusivity for the protective scale forming elements Cr and Al (more rapid formation of the scale) and a more even growth of the scale over the heater surface, so the protection is provided more rapidly and more effectively. The protective scales adhere better to the nanocrystalline structure, which results in reduced spalling. Further improvement in the mechanical stability and adherence of the scale is possible using additives of reactive metal from the group consisting of yttrium, lanthanum and other rare earth elements.

The primary advantage of an oxide scale that passivates the heater is it removes the need for additional protective coatings. This improves efficiency as there is no energy wasted in heating the coatings. As a result, the input energy required to form a bubble with a particular impulse is reduced, lowering the level of residual heat in the printhead. The majority of the remaining heat can be removed via the ejected drops, a mode of operation known as "self cooling". The primary advantage of this mode of operation is that the design is not reliant on conductive cooling, so a heatsink is not required and the nozzle density and firing rate constraints imposed by conductive cooling are removed, allowing increased print resolution and speed and reduced printhead size and cost.

Optionally, the chamber has a nozzle opening such that the pressure pulse ejects a drop of the liquid through the nozzle opening.